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Remedium

February 24, 2010

Ms. Bonita Lavelle
US EPA Region 8
EPR - SR
1595 Wynkoop Street
Denver, CO 80202-1129

Dear Bonnie,

Enclosed you will find 2 reports prepared by Billmayer & Hafferman, Inc. for Remedium Group, Inc.

1) Kootenai Development Impoundment Dam - Surface Water, Peizometer and Toe Drain Monitoring Report, 2008-2009 Water Year dated February 18, 2010

2) Kootenai Development Impoundment Dam – Elevation and Latitude/Longitude Location Survey Report, dated February 11, 2010

Both reports involve the Impoundment Dam located on Operable Unit 3 near Libby, Montana.

Please advise if there are any questions.

Robert R. Marriam

Cc: W. M. Corcoran (w/out attachments)
R. J. Medler (w/out attachments)

dwp
Enclosures

KOOTENAI DEVELOPMENT IMPOUNDMENT DAM
SURFACE WATER, PIEZOMETER, AND TOE DRAIN MONITORING REPORT
2008-2009 WATER YEAR

Billmayer & Hafferman Inc.
2191 3rd Avenue East
Kalispell, Montana 59901

February 18, 2010

A

Signature and Statement of the Professional Engineer
for the
Kootenai Development Impoundment Dam
Surface Water, Piezometers and Drain Discharge Report
February 19, 2010

I declare that to the best of my professional knowledge and belief that I meet the definition of a Licensed Professional Engineer as defined in all of the Statutes and Rules applicable to the Board of Professional Engineers and Professional Land Surveyors as described in Title 37, Chapter 1, Part 3 in the Montana Code Annotated Uniform Regulatory Act passed by the Legislature in 1995 including all Administrative Rules pertaining to engineering and land surveying that are written and adopted by the Board of Professional Engineers and Professional Land Surveyors.

I declare that I have the specific qualifications based on education, training, and experience to assess a property of the nature, history, and setting of the subject property and that I have developed and performed the appropriate inquiries in conformance with the standards and practices.

I declare that I have personally performed a site the investigation, data collection and completed this report titled the Surface Water, Piezometers, and Drain Discharge Report for the Kootenai Development Impoundment Dam, know as the subject property. This assessment has revealed the conditions discussed in the attached report in connection with the property. I declare that the statements made in this report are true to the best of my belief and professional knowledge.

MONTANA KURTIS M. HAFFERMAN 10457PE REGISTERED PROFESSIONAL ENGINEER

Kurtis M. Hafferman P.E. MT PE 10457 Date

Statement of Qualification of the Professional Engineer

Kurt Hafferman is a 1990 civil engineering graduate of Montana State University. Mr. Hafferman has over 14 years of construction experience and over 6 years as a land survey technician and is capable of recognizing existing structures, legal land locations, and past land practices. Mr. Hafferman has over 16 years of experience with the Montana Department of Natural Resources and Conservation in the Water Resources Division working on irrigation project engineering, dam safety, floodplains, and water right projects for the DNRC. Mr. Hafferman has worked as a laboratory technician for Montana State University from 1988 to 1991 in the soils and asphalt laboratories and has conducted soils analysis, soils identification and soils testing for the DNRC. Mr. Hafferman in both his positions with MSU, with the Montana DNRC, and with Billmayer & Hafferman Inc. has used and is familiar with ASTM standard testing requirements and reporting procedures.

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DEFINITIONS

Acre-feet – the volume of water covering one acre one foot deep, equal to 325,851 gallons.

cfs – measure of rate of flow in cubic feet per second, i.e. 1.0 cfs = 448.9 gpm

Embankment - A massive artificial water barrier typically created by the placement and compaction of a complex semi-plastic mound of various compositions of soil, sand, clay and/or rock and fragmented independent material particles. The friction and interaction of particles binds the particles together into a stable mass rather than the use of a cementing substance.

Flume - flume can be used to measure the rate of flow. Specific designs include the Parshall Flume, Replogle Flume, and H-Flume

Hydrographic - The science of measuring and recording surface water, i.e., hydrographic measurements will include the date, time, water temperature, velocity, flow rate, and volume of water

gpm – measure of rate of flow in gallons per minute i.e. 448.9 gpm equals 1.0cfs

Phreatic water surface – The elevation of water within an embankment dam that would be equal to atmospheric pressure. Also known as the upper limit of the groundwater table or the groundwater level in an embankment dam.

Piezometer – A small-diameter observation well used to measure the phreatic water surface or hydraulic head of groundwater in embankments.

Water Year – October 1 of any year to September 30 of the next year, i.e. October 1, 2008 to September 30, 2009

Weir - Weirs are a simple method of measuring the rate of fluid flow in small to medium-sized streams. Since the geometry of the top of the weir is known, and all water flows over the weir, the depth of water behind the weir can be converted to a rate of flow. The calculation relies on the fact that fluid will pass through the critical depth of the flow regime in the vicinity of the crest of the weir.

A. INTRODUCTION

This report focuses on the Kootenai Development Impoundment Dam (KDID) and drainage basins of Rainy Creek around the dam. The area is located at the former W.R. Grace Vermiculite Mountain mine 6 miles east of the town of Libby, Montana. The area of this report includes the drainage basins of Rainy Creek and Fleetwood Creek above the KDID, the tailings impoundment reservoir, the tailings impoundment dam, the principal spillway, the embankment piezometers, the toe drain system at the base of the dam, and the flow monitoring in the Rainy Creek channel below the dam.

The tailings impoundment dam and the subsequent water storage area behind the dam is classified as a high hazard dam and reservoir and is regulated by the State of Montana, Department of Natural Resources and Conservation Dam Safety Program (DNRC). The classification as a high hazard dam in no way reflects upon the safety or stability of the dam. The DNRC requires that the KDID inflow, piezometers, toe drains, and outflow be monitored monthly. As part of the 5-year operational permit renewal the DNRC requires that the data be compiled and provided to the DNRC. In addition, as part of the 2009 operational permit renewal, the DNRC is requiring the following three conditions be met in regards to the toe drains from the embankment;

1. The exact location of the terminal ends of the drains needs to be mapped and a plan for cleaning and maintaining the drains must be developed prior to April 15th, 2010.
2. The drains must be cleaned and maintained prior to December 31, 2010.
3. The analysis of the drain flows and piezometer water levels must be completed by December 31, 2010.

This report will use the results of the 2008 – 2009 water year monitoring program to provide data and analysis to address DNRC condition 3 above. In addition, the report will describe a means to meet conditions 1 and 2 above.

As part of the Dam Safety permit long term performance evaluation for the Kootenai Development Impoundment Dam (KDID), Billmayer & Hafferman, Inc. (BHI) maintains stream flow, piezometer and toe drain outflow records. During the 2009 water year from October 2008 to October 2009 BHI kept detailed monthly records of the following:

1. The timing, flow rate and volume of water flowing into the reservoir above the KDID
2. The timing, flow rate and volume of water that is discharged through the principal spillway
3. The timing of the phreatic water surface elevation in the 13 on-site piezometers, and
4. The timing, flow rate and volume of water discharge out of the toe drains at the base of the KDID.

The data from the monitoring program is used to provide both long term historic data for purposes of record keeping and for assessing potential changes when they occur. Monitoring data from the piezometers has been periodically recorded from 2002 until

2007 and recorded monthly from 2007 to the present. The data recorded for the piezometers has a good history, is of good to excellent quality, and can be used to predict normal piezometer behavior and data for analysis. Flow data that has been collected monthly since 2007 from the streamflow, reservoir and spillway flow data is fair to good, the records where sporadic for the 2007-2008 water year and monthly, and occasionally weekly, readings for the 2008-2009 water year. The stream flow data can be used to provide monthly flow rate data and can be used to find the peak flows in the last two years and good data for flow rates and volumes for the 2008-2009 water year.

The local precipitation and snow data is collected at Banfield Mountain which is located 2 miles due north of the KDID and is in the same climatic area. Data from the Banfield Mountain site for snowpack, snow water equivalent, and precipitation for the years from 2007 to the end of 2009, was normal to slightly below normal in 2007, normal for 2008 and below normal for all of 2009. Graphs of the water data from the US Natural Resource Service Center, National Water and Climate Center is provided in provided in Appendix B.

The piezometer and flow data was used in this report to analyze the behavior and performance of the inflow, reservoir, phreatic water surface and toe drains and their impact to the embankment based on the elevation of the phreatic water surface in the dam from October 2, 2008 to October 23rd, 2009, e.g. the 2008-2009 water year.

This report will provide conclusion about the surface water measuring system, the piezometers, and the performance of the toe drains and will provide conclusions about the short term and long term performance projections for the toe drain system. This report will also provide recommendations for meeting DNRC conditions 1 and 2, and for improving the performance of the data collection system of the surface water measurement system, the piezometers, and the toe drains. Lastly this report will provide suggestion to address the long term performance of the KDID and its relation to the toe drain system.

B. DISCUSSION

The information provided below will generally follow the four main record keeping systems used; surface water flows of Rainy Creek, flow into the reservoir, flow through the spillway, groundwater rise and fall in monitoring piezometers, and flow from the toe drains. The descriptions will progress from the most upstream measurement location on Upper Rainy Creek to the toe of the embankment in the main channel of Lower Rainy Creek below the confluence of all the toe drain flow. The descriptions will also include flow measurements taken in Lower Rainy Creek and Carney Creek to correlate the total flows from the KDID system. The following is a description of each of the measurements systems used to gather data, results of the data showing the annual timing of the peak flow rate and total volume of the inflow into the reservoir above the KDID, the timing of the rise and fall of the reservoir, the timing of the rise and fall in the phreatic water surface in the embankment, and the annual timing, peak flow rate and total volume of the outflow from the toe drain system.

B.1. Surface Water Measurement Locations

An aerial photograph from Google Earth showing the surface water flow measurement locations is shown in Appendix B. The following is a description of each location.

<u>B.1.a. Upper Rainy Creek</u>: The upper most measurements in the Rainy Creek drainage basin monitored during this project were at the Upper Rainy Creek flume labeled URC02. The timing, flow rate and volume of water flowing into the reservoir above the KDID was monitored by using a 2 ft. H-Flume installed in Rainy Creek above the confluence of Rainy Creek and Fleetwood Creek just below the switch-back on the haul road. Staff gauge readings were taken once monthly and the average daily flow rate was interpolated between monthly readings to calculate the monthly flow volumes.

<u>B.1.b. Fleetwood Creek</u>: There is no permanent measuring device located in Fleetwood Creek. The flow rates in Fleetwood Creek were measured twice using the Marsh McBirney flow meter during the monitoring period. As data was not available for Fleetwood Creek from a gauged location, an estimation technique was considered valid. In order to develop a monthly hydrograph, the ordinates of the Rainy Creek hydrograph were adjusted for Fleetwood Creek using a basin size correction and then calibrated to the actual flow measurements taken. The Upper Rainy Creek basin is approximately 5.04 $mi.^2$ and the Fleetwood Creek basin is 3.43 $mi.^2$ therefore it was determined that a 0.68 factor could be used to reduce the ordinates from the Rainy Creek hydrograph to develop the Fleetwood Creek hydrograph. The flows were then compared to the monthly flow measured on site, and a further reduction in Fleetwood Creek monthly flows were made to correlate ordinates to the actual flows measured. The flows for Rainy Creek and Fleetwood Creek were then added to develop a final monthly inflow hydrograph for Upper Rainy Creek for the total 2008 – 2009 monitoring period.

<u>B.1.c. Reservoir Level</u>: The level of the reservoir was recorded using a staff gauge placed in the reservoir and monitored once each month. A plot of the change in water surface elevation was developed for the reservoir from the monthly readings.

B.1.d. Spillway Flows: As site inspections only occurred once each month, the exact date that the flow started in the open channel concrete spillway is not precisely known. The first date it was observed was April 24th and the last day it was observed was June 26th. The actual start and end dates were extrapolated by plotting the spillway flow hydrograph and extrapolating the slope of the line to a zero flow axis on the plot and assumed the days the flow started and stopped. The total volume flowing over the spillway was calculated using the measured and extrapolated flows over the extrapolated flow duration.

B.1.e. Drain Flows: During construction of the dam, a series of twelve (12) or more drains were installed near the toe of the embankment. The flow rate out of the twelve drains is monitored once each month by using a visual inspection, a combination of weirs and flumes below the drains to gauge flow, and measurements of the water depth in each drain.

B.1.f. Lower Rainy Creek: Stream flow measurements were taken each month below the confluence of all the drain flows out of the toe drain system at a staff gauge and H-Flume and then a Replogle flume. Stream flow measurements were made using a Marsh McBirney velocity meter and the USGS method of stream discharge calculations. The flow measurement location was in Rainy Creek below the confluence of all of the drains approximately 150 ft. below the toe of the dam. In May of 2009 a Replogle flume was installed at the location below the toe of the dam and gauge height readings were taken when actual stream flow measurements were not made.

Lower Rainy Creek also has three previously installed Parshall flumes located on Carney Creek (CC02), on Lower Rainy Creek just below the Mill Pond (LRC02) and on Lower Rainy Creek just above Highway 37 near the confluence of Rainy Creek with the Kootenai River (LRC06).

A description of each of the different flow measuring devices, a description of the spillway flow measurements, and a description of the toe drains and flow measurements is provided in section B.1.1. below.

B.1.1. Surface Water Flow Measurement Descriptions

B.1.1.a. Upper Rainy Creek H-Flume URC02: On Upper Rainy Creek, above Fleetwood Creek and the above the reservoir is a 2 foot H-flume which was used to monitor the inflow from the Upper Rainy Creek drainage basin. A photograph of the flume is shown in Appendix A, photograph A.1.1. A copy of the data collected at this site is provided in Appendix B in a data table and includes copies of staff gauge readings for a 2-foot H-flume. A hydrograph based on data collected at this site between October 2008 and September 2009 is shown in Appendix B. Rating tables for a 2-foot H-flume provided in Appendix C, section C.1.

B.1.1.b. Reservoir: The reservoir has a staff gauge located to actively monitor water elevation in the reservoir. Photographs of the location of the gauge in the reservoir impoundment area and a photograph of the staff gauge location are shown in Appendix A, photographs A.1.2 and A.1.3. Reservoir level data and a graph of reservoir levels is provided in the Appendix B data table. The actual reservoir elevation was brought in during a recent elevation survey and a staff gauge rating table was developed for the true reservoir level elevation in NAVD 88 datum[1]. This rating table is provided in Appendix C, section C.2.

B.1.1.c. Principal Spillway: The principal spillway is a concrete box culvert that flows into a uniform 8 ft. wide concrete chute spillway. The concrete spillway starts below the box culvert, is on a uniform slope, has a uniform width, and is approximately 965 feet long. A photograph is shown in Appendix A, photograph A.1.4. Because the shape and slope is uniform a rating table for the spillway based on size and slope was developed using FlowMaster®, with Manning's equation for uniform flow in a concrete open channel. A photograph of the location used to measure the water depth in the spillway is shown in Appendix A, photograph A.1.5. Flow data for the spillway is provided in the Appendix B data table and a rating table from FlowMaster® is provided in Appendix C, section C.3.

B.1.1.d. Weir/H-Flume 1-2-3-4: This weir/flume lies below the confluence of toe drains 1,2,3, and 4. Originally the accumulated flows of these drains were passed over a 1 ft. rectangular weir. However the resulting flows from these drains occasionally exceeded the capacity of this weir during seasonally high flows. In May of 2009 the rectangular weir was replaced with a 1 foot H-flume capable of measuring flows well in excess of the current drain flow discharge capability. Photographs of the weir and flume are shown in Appendix A, photographs A.1.6. and A.1.7. Flow data is provided in Appendix B and the rating table is provided in Appendix C, section C.4.

B.1.1.e. Weir 5: Weir 5 consists of a 90° v-notch weir placed below Drain 5. A photograph of both the weir and drain is in Appendix A, photograph A.1.8. Flow data is provided in Appendix B, and a rating table for a 90° v-notch weir is provided in Appendix C, section C.5.

B.1.1.f. Pipe Drain 6: Drain 6 is a 13-inch steel pipe that free discharges approximately 2 ft. above the ground surface. No weir was placed below Drain 6 as the flow from this drain could be calculated based on water depth measurements in the free outflow using the equation for velocity at a free outfall times the area of the water. Photographs of the drain at the outfall are provided in Appendix A. photograph A.1.9. and flow data and a hydrograph of the 2008 – 2009 drain flow is provided in Appendix B along with the data table. A rating table for depth of water versus discharge is provided in Appendix C, section C.6.

B.1.1.g. H-Flume 7-8: Flume 7-8 is a 0.5 foot H-flume placed below drains 7 & 8. Attached in Appendix A, number A.1.10 is a photograph of the flume and a rating table for a standard 0.5 ft. H-Flume is provided in appendix C, section C.7. Flow data has only been recently collected and is sporadic but it is provided in the Appendix B table.

[1] KDID Elevation and Latitude/Longitude Location Survey Report, BHI 1-19-2010

B.1.1.h. H-Flume 10-11-12: Below drains 10-11-12 is a 1.0 foot H-flume. Attached in Appendix A, is photograph A.1.11. of the flume, a rating table for a 1.0 foot H-flume is provided in appendix C, section C.4 and the flow data and hydrograph are provided in the Appendix B table.

B.1.1.i. Weir 12: Weir 12 is a 90° v-notch weir below drain 12. The data collected and a hydrograph of the flow from this weir is provided in Appendix B. A photograph of the weir is shown in Appendix A, number A.1.12 and the rating table for a 90° v-notch weir is provided in Appendix C, section C.5.

B.1.1.j. Flume LRC01 (Lower Rainy Creek- below impoundment): Resultant flows from all embankment drains accumulate just below drain 6 and originally were channeled through a 2 foot H-flume at LRC01. Discharge from the spillway does not pass through this flume. This flume routinely over topped during the spring and early summer and was replaced on May 27, 2009 with a Replogle[2] flume. Flow is also measured at this location with a Marsh McBirney flow meter. A photograph of the original 2 ft. H- Flume is shown in Appendix A, photograph A.1.13. The Replogle flume is shown in Appendix A, photograph A.1.14. and a photograph of the staff gauge in the flume is shown in photograph A.1.15. The data for this location is provided in the Appendix B data table and the rating table for the 2 ft. H-flume is provided in Appendix C section C.1. The Replogle flume rating table is provided in Appendix C, section C.8.

B.1.1.k. Parshall Flume CC02: Carney Creek has a 0.75-foot Parshall flume located above the confluence with Rainy Creek. A photograph of the downstream side of this flume is shown in Appendix A, photograph A.1.16. The data for this location is provided in Appendix B data table and the rating table for the 0.75 ft. Parshall-flume is provided in Appendix C, section C.9.

B.1.1.l. Parshall Flume LRC02: Flume LRC02 is a 1 ft. Parshall flume located below the lower millpond and below the Carney Creek confluence on Rainy Creek. A photograph of the flume is shown in Appendix A, photograph A.1.17. The data collected from this flume is provided in Appendix B data table and the rating table for a 1 ft. Parshall flume is provided in Appendix C, section C.10.

B.1.1.m. Parshall Flume LRC06: Weir LRC06 in a 1-ft. Parshall flume just like LRC02 and is located directly above the Highway 37 road crossing on Rainy Creek. A photograph of this flume is shown in Appendix A, photograph A.1.18. The data collected from this flume is provided in Appendix B data table and the rating table for a 1 ft. Parshall flume is provided in Appendix C, section C.10.

B.2 Piezometer Descriptions

The static water elevation (phreatic water surface) through the KDID embankment was monitored in the 13 (thirteen) on-site piezometers on the dam. The depth to the phreatic water surface was measured within ±0.01 ft. once each month using a GeoTech® Water

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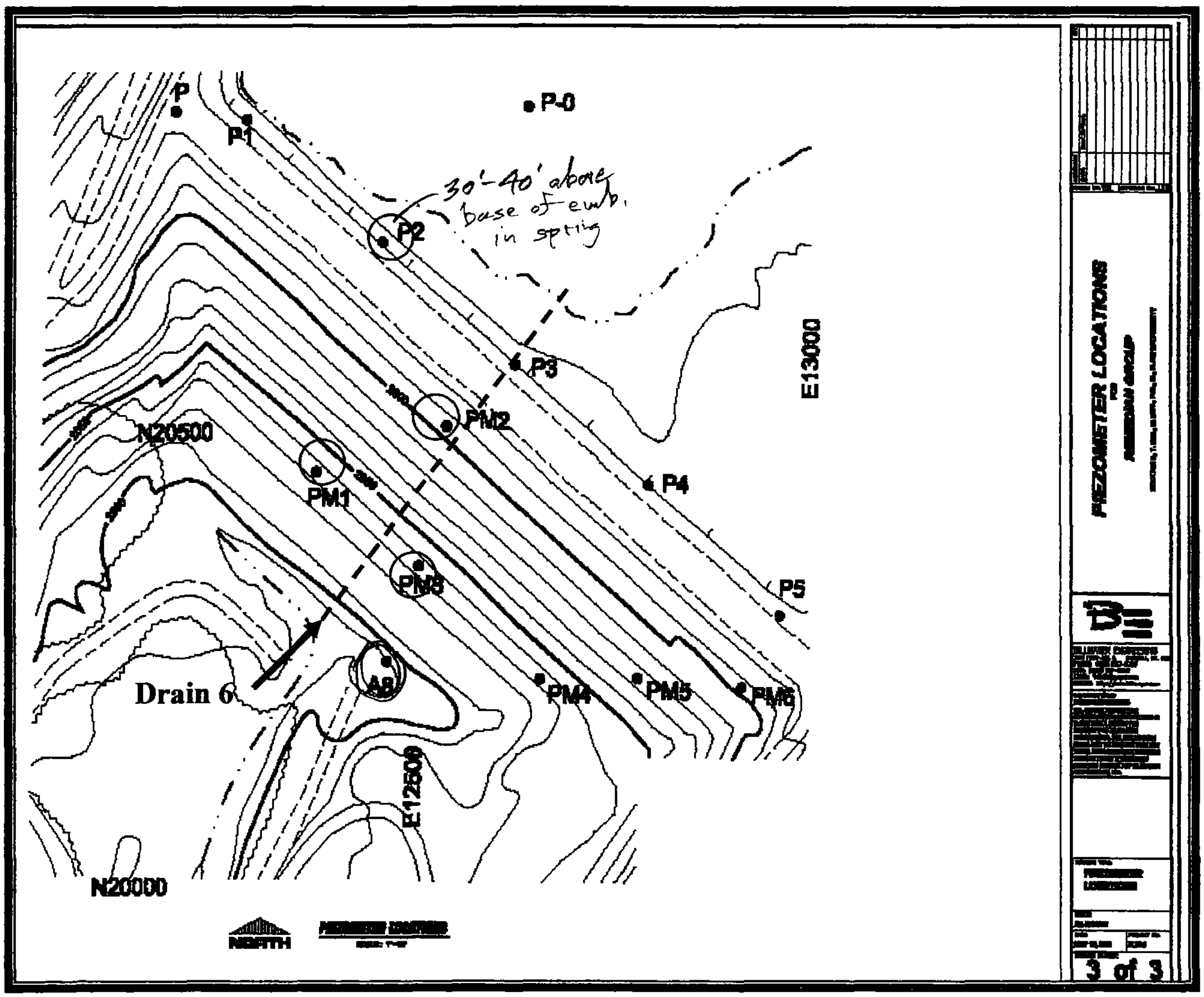
[2] http://www.usbr.gov/pmts/hydraulics_lab/winflume/

Level 300 electronic well probe. Solinst® Pressure Transducers L100 and L300, accurate to within ±0.01 ft. were placed in piezometers A8 and P2 respectively and were set to record at each 10-minute intervals during the day. The transducer measurements were used to correlate the monthly measured elevations to assure that the shape of the month-to-month data curves correlated to minute-by-minute data curves.

A water level reading is obtained monthly from each piezometer except P-O, as discussed below. Piezometers P, P1, P3, P4, P5, and PM3, PM4, PM5 and PM6 are typically noted as "dry" throughout the year. There will occasionally be water at the bottom of these normally "dry" piezometers but is usually attributed to surface water flow using the casing as a pathway to the bottom and typically occurs during or just after a rain or snowmelt event. Piezometers A8, P2, PM1 and PM2 typically have water at varying depths in them throughout the year.

A map of the piezometer locations from the 1991 Harding Lawson report is shown in Figure 1 below and is shown in a larger format in Appendix D to this report.

Figure 1: Piezometer Locations



The locations of the four active piezometers are circled and the centerline axis of the dam, also assumed to be the location of the "toe drain" now referred to as Drain 6, are shown. Shown in Figure 2 below and in Appendix D is a Google Earth Image with a GPS overlay that shows the locations of the piezometers as recently recorded with the Garmin GPS 76 CSx. As can be seen the piezometer locations in the Harding Lawson map are as accurate as that shown with the Garmin GPS.

Figure 2: Piezometers from GPS Locations

As shown in Figure 1 and Figure 2 above piezometer A8 is located at the toe of the embankment, PM1 is located on the down stream face, second lift line above the toe of the embankment, PM2 is located on fourth lift line, just below the crest, and P2 is on the upstream face of the dam, approximately 7 ft. below the top of the crest. As can be seen, all of the active piezometers are in direct alignment with the main toe drain, Drain 6, located along the centerline axis of the dam.

Piezometer P-O is located approximately 250 ft. northeast of the crest in the reservoir and was found to be a 2-inch PVC casing with two ¼-inch PVC tubes inside the casing. This piezometer appears to require an air pump and pressure gauge to be able to obtain a reading. Attempts to obtain a reading to date have not been successful and it is assumed the tubes have leaks or the piezometer is dry and discharging air at the bottom.

Sections of the piezometer casings that are above ground have been deteriorated by sunlight. The sections were repaired by Chapman Construction during the spring and summer of 2008. The tops of the casings were replaced or repaired as necessary, with reference points set prior to repair to assure that the elevations of the casing tops did not change. All piezometers are now in good condition and all of the piezometer casings were open and unobstructed to the bottom. Fence posts have been established next to each piezometer to ease in location in the winter months when there is deep snow and metal tags have been attached to the metal top on each piezometer to assure identification consistency when recording data. A photograph of the top of piezometer 'P' before it was repaired is shown in Figure 3 below.

Figure 3: Piezometer 'P'

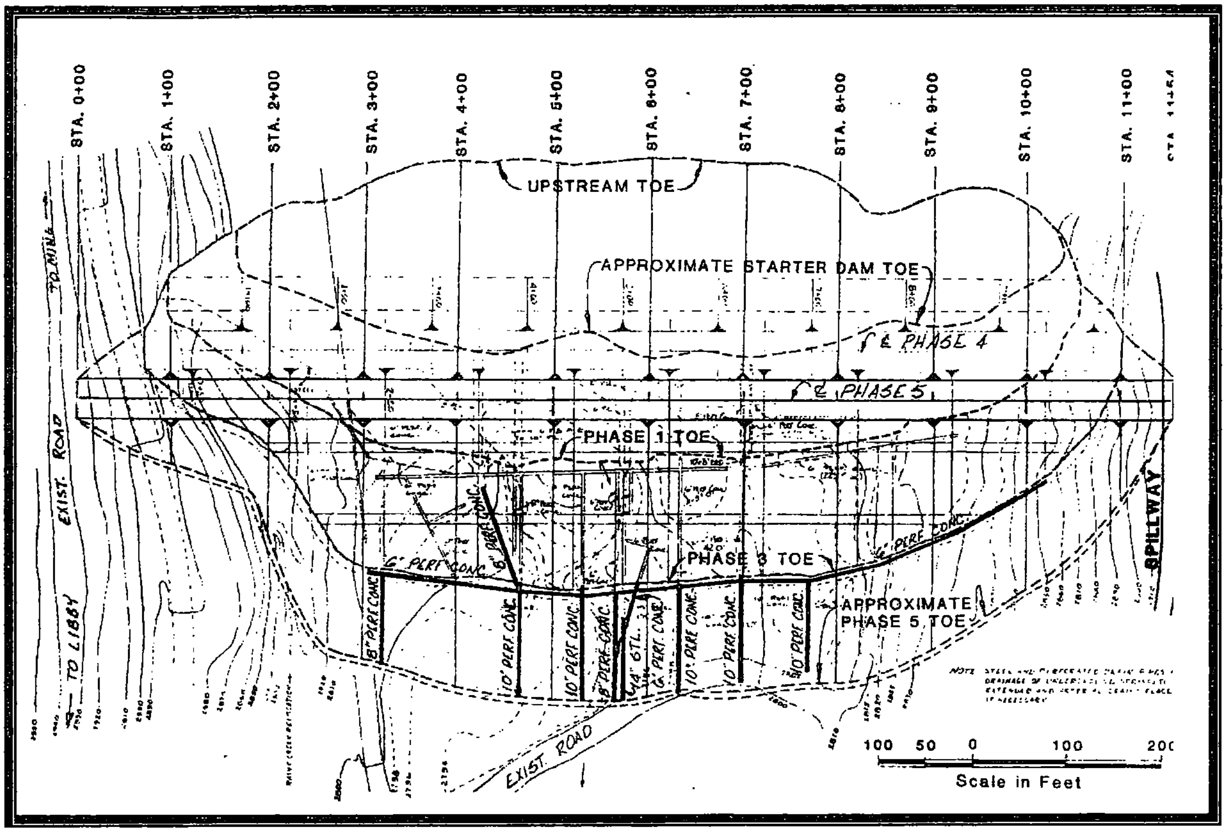
Data from the piezometers has been collected during most months from June of 2002 until June of 2007 when BHI took over as the engineer of record. Data has been collected monthly since June of 2007. The data from June 2002 to October 2009 is presented in a table in Appendix D to this report. Also provided in Appendix D are the individual hydrographic plots of each of the active piezometers, a composite hydrograph showing the plots of all piezometers together, as well as a comparison of all the active piezometers and the inflow hydrograph.

B.3. Toe Drain Descriptions

B.3.1. Historical Toe Drain Descriptions

The records are unclear as to when the various drains were installed and when they were extended. The best available information is from the September 1981 Phase 1 Inspection report which included a cross section and plan view. The plan view of the drains is shown in Figure 4 below. Larger 11x17 format copies of the Plan View and Cross Sections from the Phase 1 report are provided in Appendix E to this report.

Figure 4: Plan View from 1981 Phase 1 Report



As can be seen, seven (7) drains are shown extending to the "Approximate Phase 5 Toe". It appears that the plan was to have the 6-inch perforated reinforced concrete pipe (RCP) laid parallel to the toe and then extend the eight perforated concrete pipes to the toe. The perforated pipes are shown as a combination of 8-inch and 10-inch reinforced concrete pipes (RCP) and the one 14-inch O.D. steel (13-inch I.D.) pipe (currently referred to as Drain 6).

It is not apparent if the drains were extended beyond the 10-inch perforated pipes at some point during the life of the dam or if the 10-inch pipes were changed. Clearly what is in place now is a combination of 8-inch and 10 –inch RCP, 10-inch and 12-inch corrugated metal pipe (RCP) and the one 14-inch O.D. steel pipe as described in section B.3.2 below.

A photograph of the inside of Drain 3, shown in Figure 5 below, appears to show that at least the last 5 ft. of this drain was extended as there is an apparent headwall or terminal end of one pipe and then the extension to the toe.

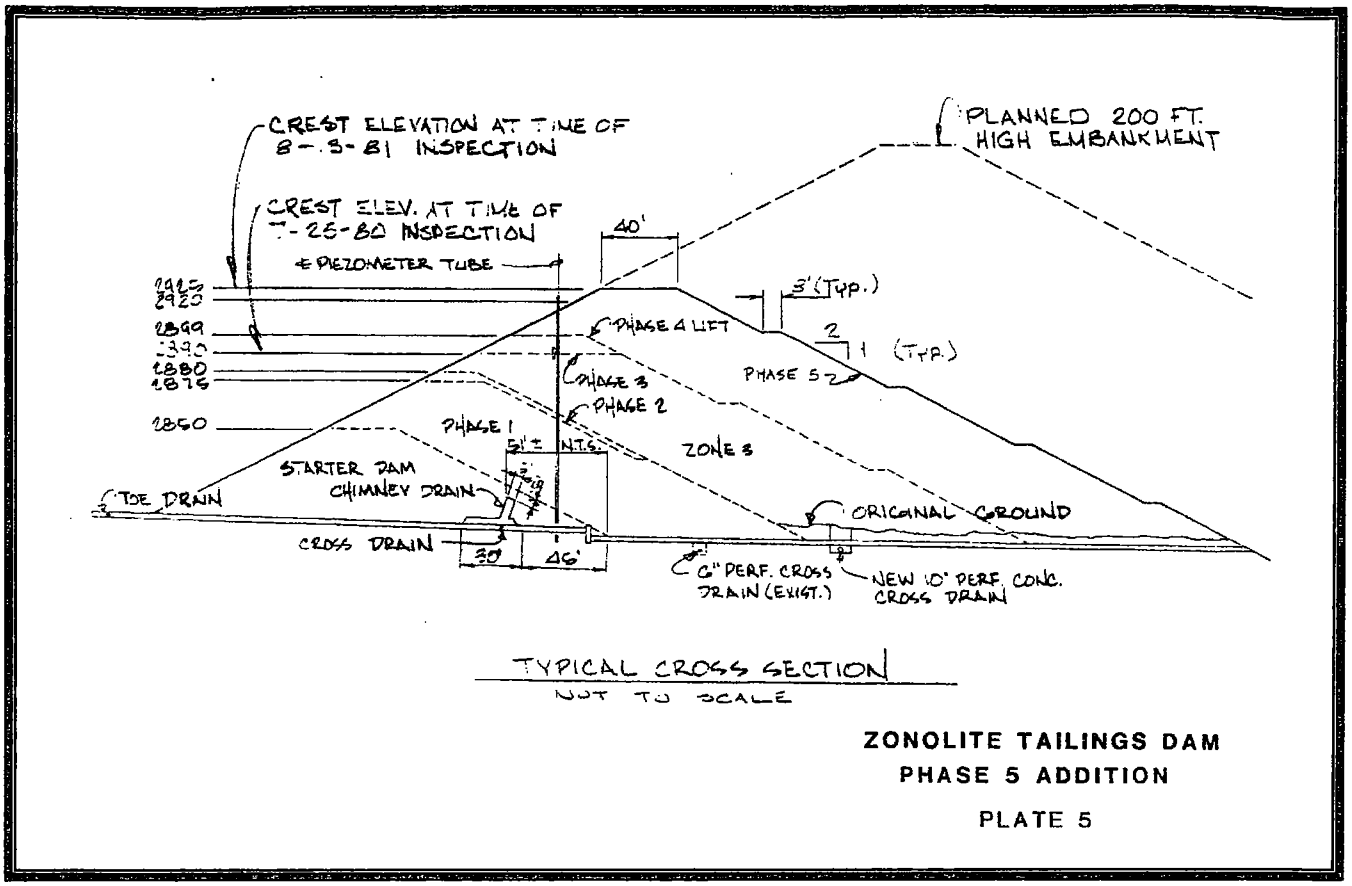
Figure 5: Inside Drain 3

The other document that gives some indication of the drain configuration is the cross section also from the Phase 1 report provided in Figure 6 below. A larger, 11x17 format of the cross section is also provided in Appendix E, page E.2.

As can be seen in Figure 6 below, it appears that the drain system started at the upstream toe, goes downstream to a cross drain, which is shown as a "chimney drain" in the starter dam, then through what appears to be a drop, then connects into to a 6-inch perforated RCP cross drain shown as "existing", then to a "new" 10-inch perforated cross drain and then exiting at the toe.

It should be noted that the Phase 5 lift was the last lift and the current elevation of the crest is 2927.6 ft. The current measured height of the embankment dam, from the toe of the dam at the ground surface at piezometer A8 to the crest of the dam, is 134.8 ft.

Figure 6: Cross Section of the Embankment



B.3.2. Existing Toe Drain Descriptions

The following toe drains are all the drains that have been located and are currently flowing water at the toe of the embankment either all year or part of the year. Each of the drains are monitored each month by checking the flow depth in each drain, checking to see if there are any fines or soils in the drain discharge, taking the water temperature, and photographing the outside and inside of each drain to develop a maintenance record. The gauge height in each of the flow measuring devices discussed in section B.1.1.d. through B.1.1.j. above are measured and the gauge data, and the flow depth data is used to calculate flow rates for each of the individual drains as well as the total drain flow. Photographs of the outside and inside of each of the drains are provided in Appendix A.2.

The following is a description of each of the drains, a brief description of the flow characteristics of each drain and a reference to photographs in Appendix A.2.:

B.3.2.a. Drain 1: A 12-inch corrugated metal pipe (CMP) in the left groin. This drain only flows in the late spring to early summer. Typically when the drain flows the flow is clear and steady and can occasionally be ½ full. Photographs of outlet and inside of the drain are shown in Appendix A, photographs A.2.1. and A.2.2.

B.3.2.b. Drain 2: Also a 12-inch CMP in the left groin. This drain only flows in the late spring to early summer just as Drain 1 and typically when the drain flows, the flow is clear and steady and can occasionally be ½ full, very similar to Drain 1. There have been report references that have indicated that these drains may flow when the spillway flows and may be indicative of either water leaking from the box culvert or the open channel spillway, under the entrance to the box culvert, or in the spillway channel leading to the box culvert entrance. That reference has not been confirmed or disproven other than there is a similar start and stop pattern as opposed to year around flow as in all of the other drains. Photographs of outlet and inside of the drain are shown in Appendix A, photographs A.2.3. and A.2.4.

B.3.2.c. Drain 3: An 8-inch reinforced concrete pipe (RCP) near the bottom of the left groin. This drain flows all year and is generally low to very low most of the year and flows ¼ to ½ full during the spring and early summer. The flow is always clear and steady. Photographs of the outlet and inside of this drain are shown in Appendix A, photographs A.2.5. and A.2.6. and as is shown in Figure 5 above.

B.3.2.d. Drain 4: An 8-inch RCP with the bell end exposed. The drain is located 5 ft. away from drain 3 in the same location away from the left groin. This drain has very similar flow patterns to Drain 3 and flows all year and is generally low to very low most of the year and flows ¼ to ½ full during the spring and early summer. The flow is always clear and steady. Photographs of the outlet side and inside of this drain are shown in Appendix A.2, photographs A.2.7. and A.2.8.

B.3.2.e. Drain 5:, A 12-inch CMP near the center of the impoundment dam. This drain appears to be fairly old and is fair to poor as it has interior rust and metal loss. Photographs of the outlet side and inside of this drain are shown in Appendix A.2, photographs A.2.9. and A.2.10.

B.3.2.f. Drain 6:, A 14-inch O.D., 13-inch I.D., steel pipe near the center of the embankment. This drain consistently runs the most amount of water and will respond the quickest to changes in upstream reservoir level conditions. The drain flow is always clear and steady. Photographs of the outlet side and inside of this drain are shown in Appendix A.2, photographs A.2.11. and A.2.12.

B.3.2.g. Drain 7 and 8 : These are a pair of drains located together with Drain 7 directly above drain 8. The drains are on the right side of the center embankment. Drain 7 is a 10-inch RCP and Drain 8 is a 12-inch CMP half buried in silt. Drain 7 has been full of dirt and roots and never flows. Occasionally water will saturate the soil and will seep out of the pipe, but generally it is dry. Water is known to emerge from directly below this drain so it is apparent that the water that should be in the drain is flowing on the outside. Several futile attempts have been made to clean this drain. Drain 8 is a 12-inch CMP that is in fair to poor shape. There appears to be rust on the inside and the metal in the pipe is fairly thin. Drain 5 and Drain 8 have similar characteristics. Drain 8 flows year around but the flow is low to very low for most of the year. These drains are in an area that is constantly saturated with water and the water emerges from below Drain 7, and around and below Drain 8. The flow appears to be inconsistent but is always clear. In the fall of 2009, a new 0.5 ft. H-Flume was installed to monitor the flows. Photographs of the outlet side and inside of these drains are shown in Appendix A.2, photographs A.2.13., A.2.14., A.2.15., A.2.16., and A.2.17.

B.3.2.h. Drain 9: A 10-inch RCP drain located approximately 210 feet left of the right groin. This drain flows water year around and the flow will rise and fall with the change in reservoir level. The flow from this drain is steady and clear at all times. A photograph of the inside and outlet of this drain is shown in Appendix A.2, photographs A.2.18 and A.2.19.

B.3.2.i. Drain 10 and 11: A pair of drains located to the right of Drain 9 approximately 125 ft. from the right groin. Drain 10 is a 12-inch CMP and Drain 11 is a 10-inch RCP. Both of these drains flow year around and the flow will rise and fall with the change in reservoir level. The flow from these drains is always steady and clear. Both of these drains exhibit an unusual characteristic in that they contain gravel on the invert of each pipe. The gravel appears to be a uniform ¾-inch minus round gravel. The gravel can be seen in photographs of the inside of the pipes in A.2.21 and A.2.22. A photograph of the outside of these drains is shown in Appendix A.2, photograph A.2.20.

B.3.2.j. Drain 12: An 8-inch RCP located in the right groin at the toe of the dam. The drain was originally clogged with tree roots from the willow trees located to the left of the drain. In early May of 2008, water was seen emerging from the embankment approximately 10 ft. up from the outlet of this drain. A very large wad of roots was pulled out of the drain and the embankment water stopped flowing and the drain is now free flowing. The flow from this drain also follows the rise and fall of the reservoir levels and flows all year around. The flow is clear and steady and during the spring the pipe will often run full pipe flow. A photograph of the outlet and inside of this drain is shown in Appendix A, photographs A.2.23 and A.2.24.

B.3.2.k. Drain 13: This drain was discovered in the spring of 2009 while installing H-Flume 10-11-12. The drain is a 6-inch CMP in poor condition although the inside is clear and unobstructed. The drain has thin metal and the inside is coated with rust. The drain flows with very little flow although the flow is steady throughout the year. A photograph of the outlet and inside is shown in Appendix A.2, photographs A.2.25. and A.2.26.

C. RESULTS

All of the data gathered is included in the appendix as discussed above. A summary of the hydrographic data for the KDID, the timing, low and peak flow rate and volume, and/or peak elevation of each of the monitoring locations, are provided in Table 1 below;

TABLE 1: HYDROGRAPHIC RESULTS 2008-2009 WATER YEAR

LOCATION	QLOW (gpm)	QPEAK (gpm)	Vol (AF)	Elevation (ft. MSL) LOW	Elevation (ft. MSL) PEAK	Date LOW	Date PEAK
Upper Rainy Cree	43	4100	1154			10/23/09	5/1/09
KDID Reservoir				2998.89	2901.80	10/23/09	5/19/09
Piezometer P2				2796.71	2826.92	12/1/08	5/27/09
Piezometer PM2				2810.44	2827.52	1/15/09	5/1/09
Drain 6	100	837	580			12/12/08	5/19/09
Lower Rainy Creek	184	1824	1020			12/12/08	5/19/09
Concrete Spillway	0	1320	111				4/30/09

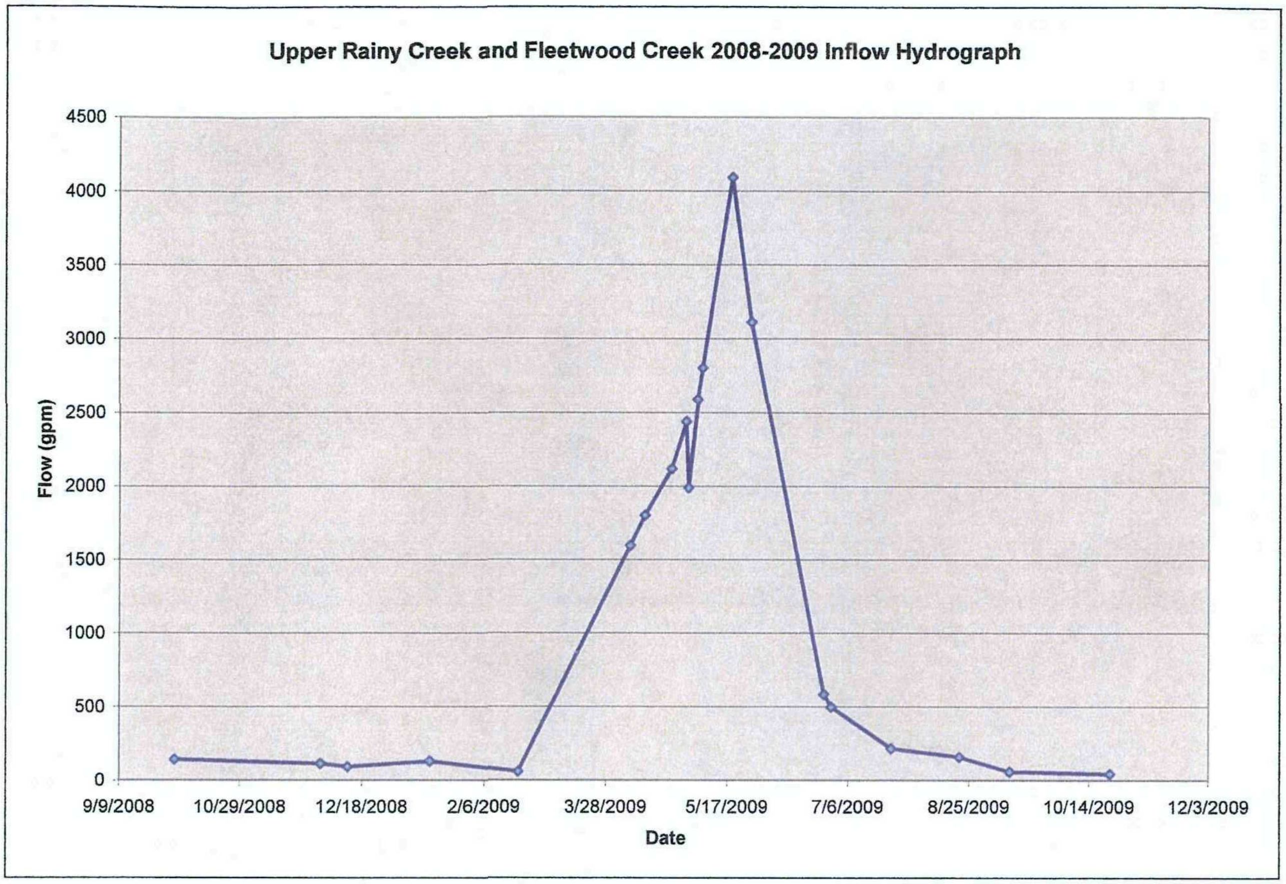
The individual results for each of the measurement data locations are described below;

C.1. Surface Water Flow Results

C.1.1 Upper Rainy Creek: Using the flow data for Upper Rainy Creek (URC02) and the Fleetwood Creek extrapolated data, inflow hydrographs were developed for all of the data gathered from October 1st 2008 through October 23rd, 2009.

The hydrograph for Upper Rainy Creek and Fleetwood Creek in the 2008-2009 water year is shown in Figure 7 below. Using the monthly flow data of this hydrograph is was found that the peak flow rate was 4,100 gpm (9.1 cfs). Area under the hydrograph is the total volume of flow during the measuring period, in gallons, which was converted to the standard volume unit in Montana, acre-feet, and was found to be 1,154 acre-feet (376,032,100 gallons).

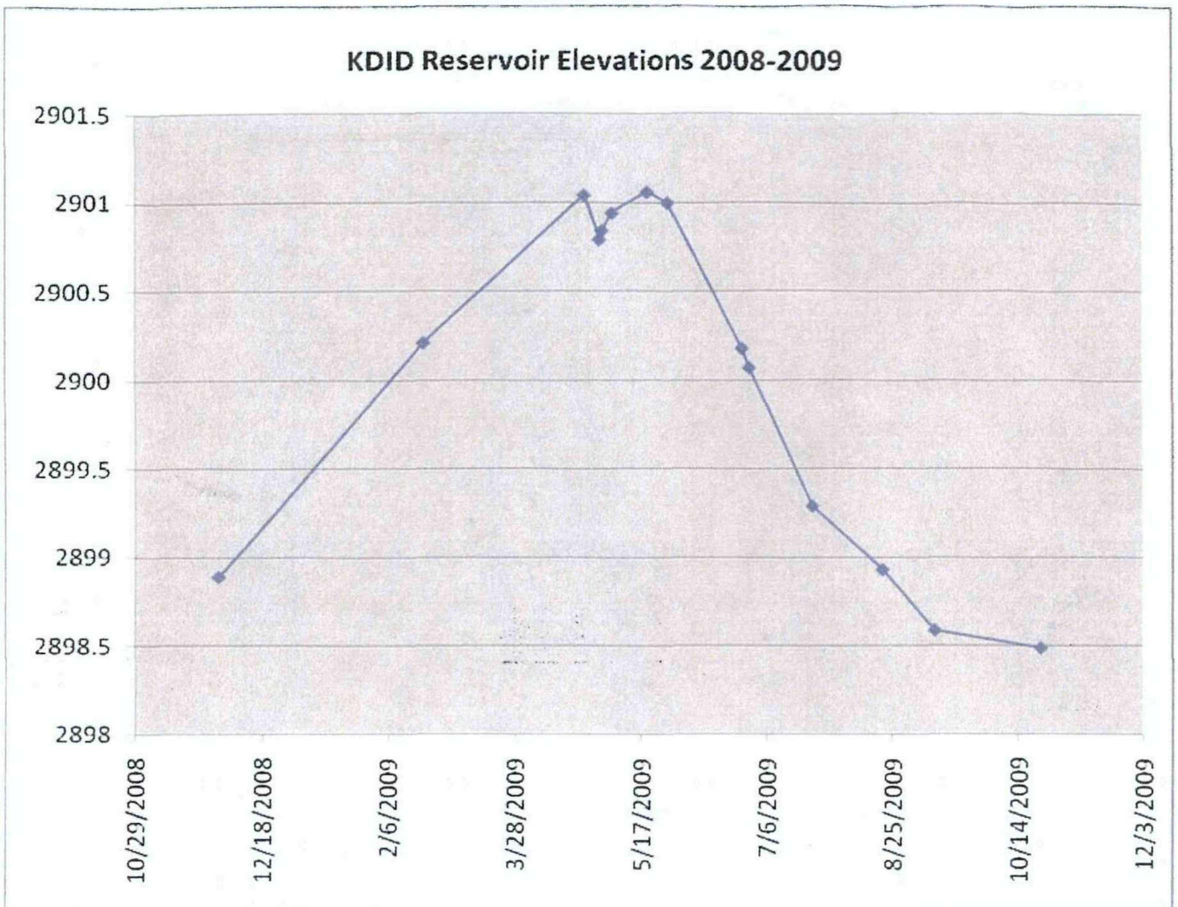
Figure 7:



C.1.2. Reservoir: The peak flow periods from Upper Rainy Creek always cause the reservoir impoundment's water level to rise as it did in the 2008-2009 water year. Once the water level reaches the elevation where it is able to cross an earthen berm at the entrance to the principal spillway channel the water flows into the entrance to the box culvert and the principal spillway and the reservoir rise starts to slow.

In 2009 it appears that the minimum water surface was near 2898.89 and the maximum reservoir level rose 2.21 ft. to an elevation of 2901.80, approximately 0.8 ft. above the entrance to the spillway channel, 1.8 ft. above the entrance to the box culvert, on May 27th, 2009. The hydrograph of the reservoir elevation is shown in Figure 8 below.

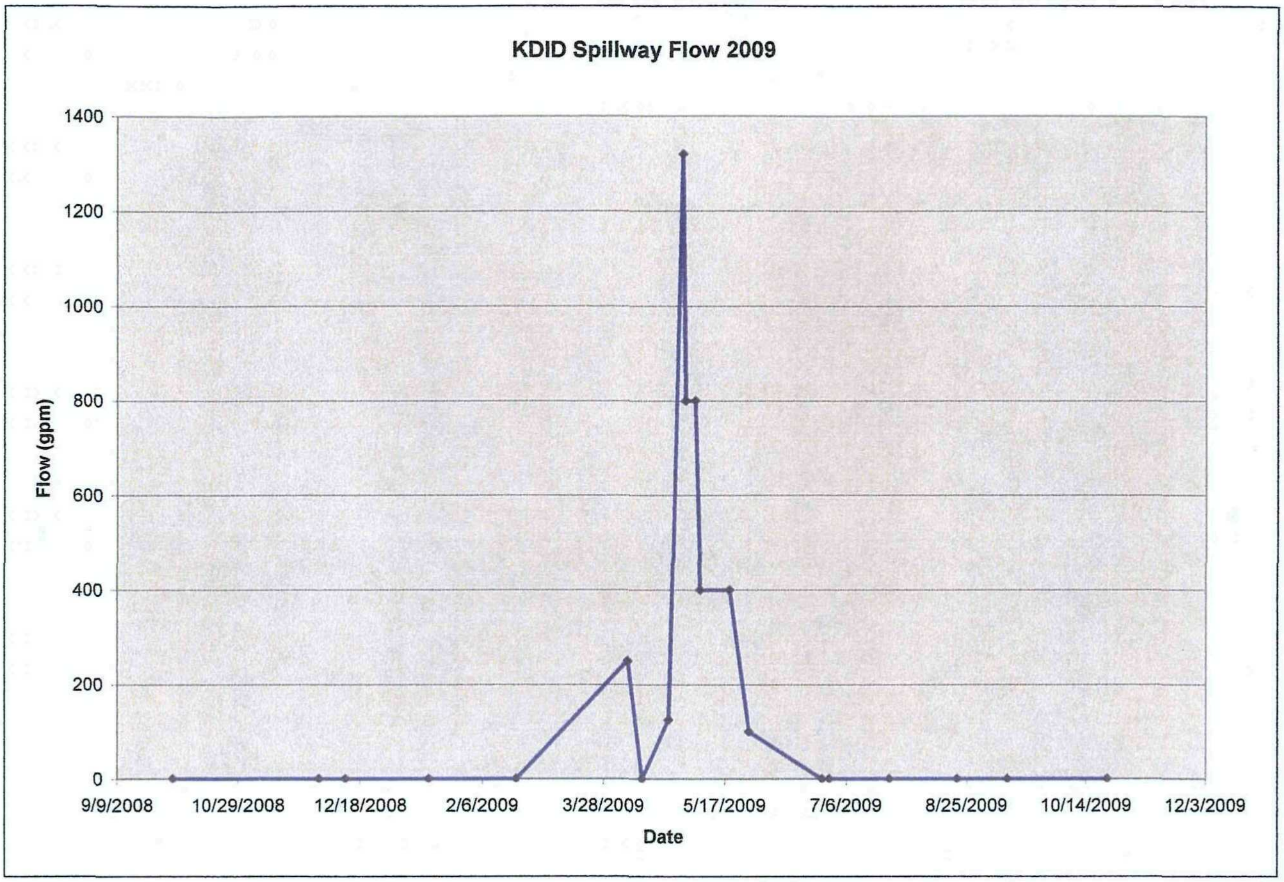
Figure 8:



C.1.3. Spillway Flow: There is not always personnel on site when the spillway starts to run and it appears to start and stop suddenly. As soon as water is physically observed in the spillway, the depth of flow is recorded and it is assumed to run steady until the next observation.

An approximate flow depth of 0.03 feet (3/8-inch) was recorded in the first part of April of 2009 and by mid April had ceased to flow. In late April the spillway was observed to be flowing again, and it appears that peak flow occurred by mid May and by late May or early June the flow in the spillway ceased for the year. A hydrograph of the spillway flow for the 2008 – 2009 water year is shown in Figure 9 below;

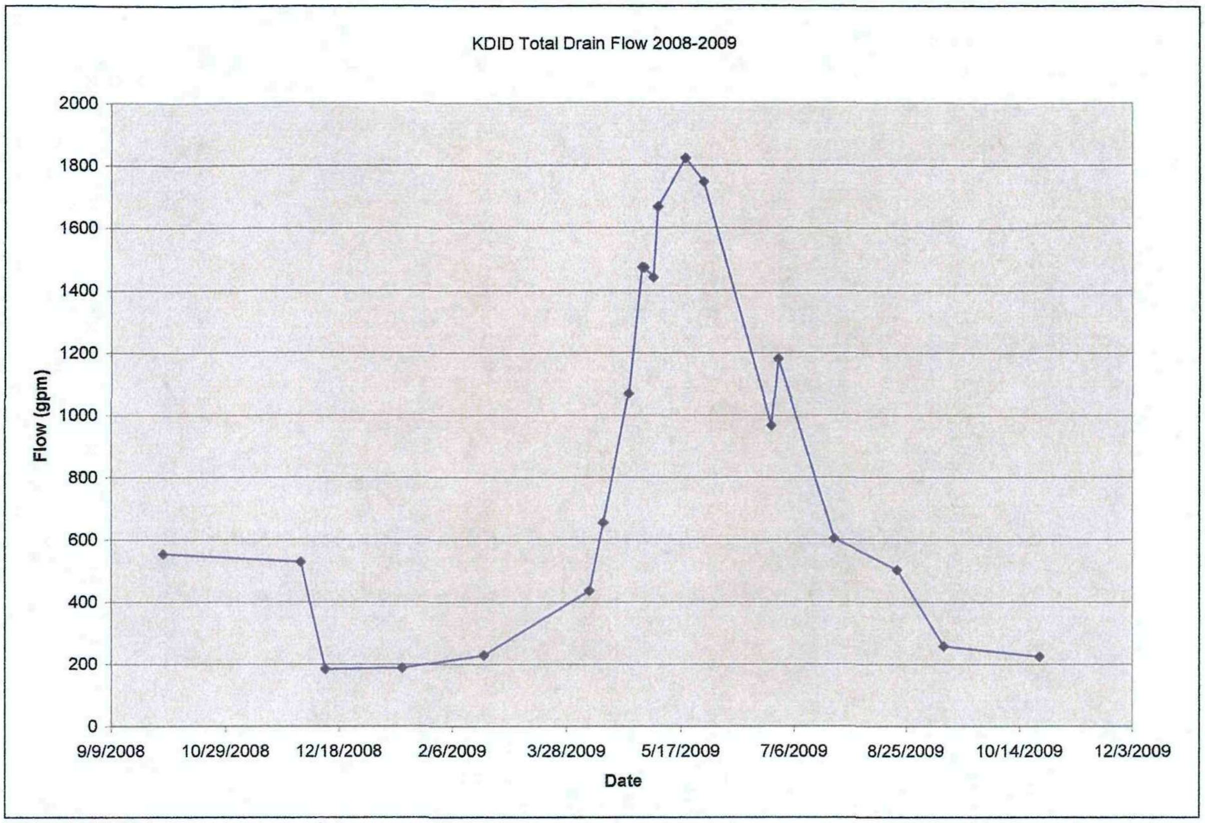
Figure 9:



The peak flow rate observed in the spillway was on April 30th, 2009 at flow depth of 1.0 inches and a flow rate of 1,320 gpm. Using the flow data for the spillway it was calculated that approximately 111 acre-feet (36,330,000 gallons) of water passed over the principal spillway in the 2008 -2009 monitoring period. It is interesting to note that the peak spillway flow nearly equaled the peak drain flow and during the short duration the spillway ran, it conveyed 9.8% of the total volume of water that flowed out of the drains and spillway.

<u>C.1.4. Drain Flow</u>: A hydrograph of the total outflow from the drains below the KDID embankment as measured at the LRC01 location is shown in Figure 10 below;

Figure 10:

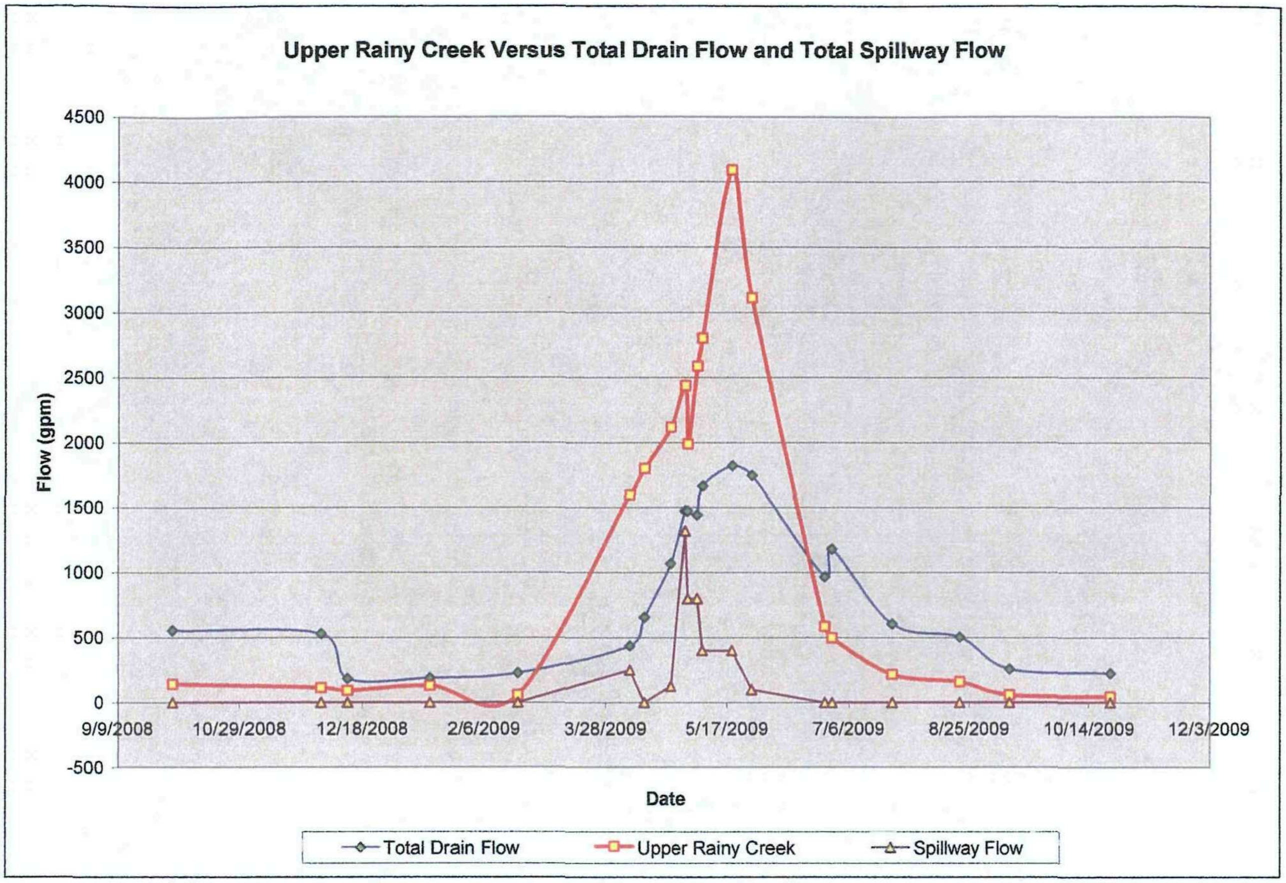


Using the flow data from the drain flows below the embankment it was found that the peak flow from the toe drains was 1,824 gpm (4.05 cfs) and it was calculated that 1,020 acre-feet (332,368,000 gallons) of water passed through the embankment and flowed out of the drains. The most active of the drains is Drain 6 which contributed 837 gpm (46%) to the peak drain flow and contributed 580 acre-feet (57%) to the total drain flow volume.

<u>C.1.5.Total KDID Inflow and Outflow</u>: The total combined volume of water that flowed out of the drains and spillway is 1,132 acre-feet (368,863,300 gallons). Subtracting the Upper Rainy Creek inflow from the drain and spillway flow shows that there is a loss of 23 acre-feet (7,500,000 gallons) of water between the inflow and the outflow. The net loss is generally attributed to flow through the embankment that is remaining as groundwater in both the tailings in the reservoir and is flowing under and past the toe of the embankment. The 23 acre-feet also represents less than 2.0 % of the total inflow and may also represent slight errors in flow measurements and volume calculations when only monthly flows are used to calculate monthly volumes.

A graph comparing each of the hydrographs, inflow, spillway flow and drain flow, is shown in Figure 11 below;

Figure 11:



As can be seen, the general shape and seasonal timing of the Upper Rainy Creek inflow, the spillway flow, and the total drain flow hydrographs have similarities. As can be seen in the inflow hydrograph early snowmelt/runoff started in the upper basin in late February, had an early peak flow in the first week in April, decreased slightly at the end of April and then increased again until it peaked sharply in late May, and then steadily decreased until late August to mid September when it returned to base flow.

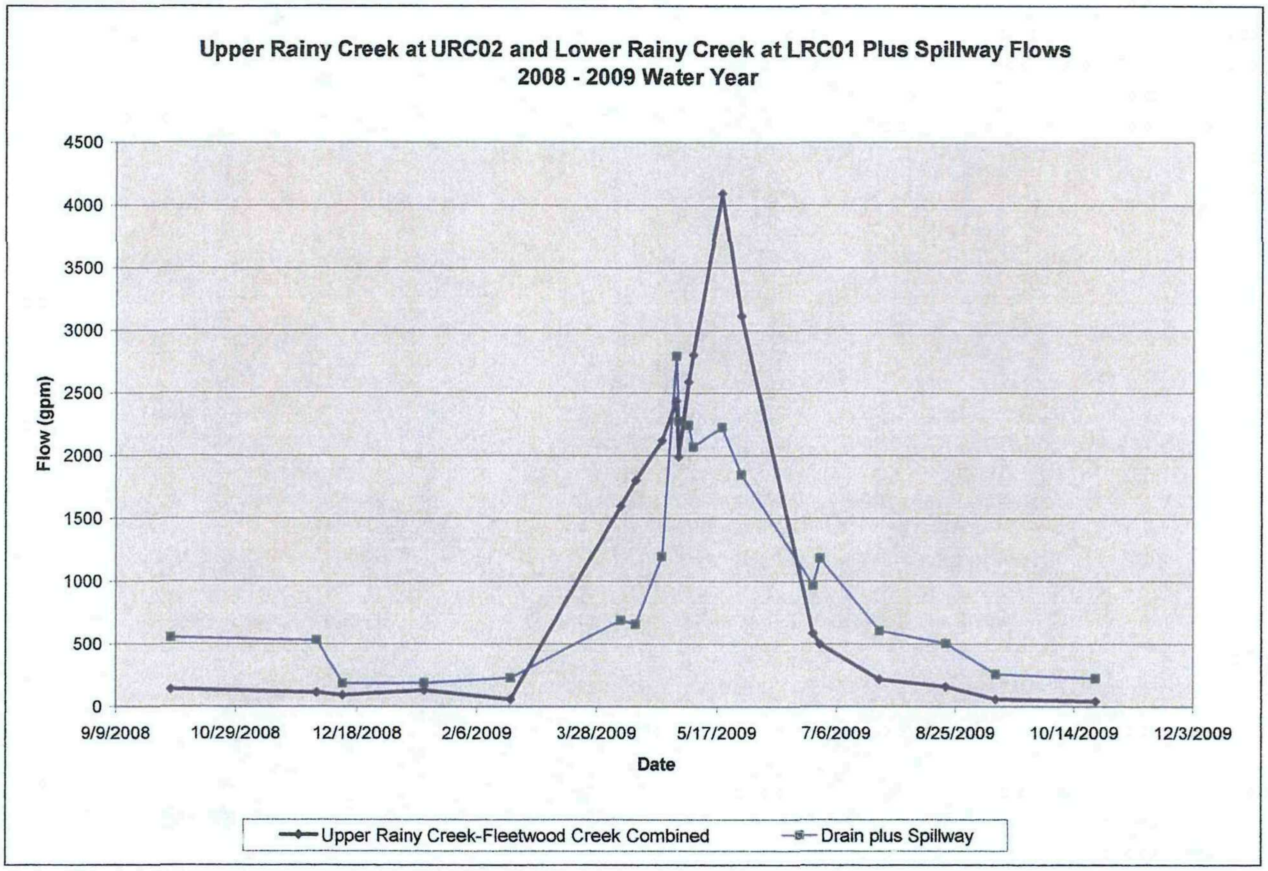
The drain flow had a steady base flow until early March and slowly increased and until the first week in April when the drain flow increased sharply and then decreased slightly in late April just as the inflow had. The drain flow rose sharply just ahead of the peak in the inflows, then peaked in late May and then decreased steadily until late June. When the spillway flows stopped in late June it appears that there was a sudden increase in the drain flows for a short period, and then the drain flows continued to decrease until late August when both the inflows and drain flow hydrographs started to flatten out and by mid September had both returned to base flow.

As can be seen, the spillway had no flow until late March when the inflow first started to rise. The flow was low but steady by the end of March but had ceased running in early April, then rose sharply the second week in April about the time of the early peak on the inflow hydrograph. As the spillway flow started to decrease, the drain flows started to increase. The decrease in spillway flow stabilized about the same time the peak of the inflow occurred, then decreased steadily until the flow ceased in late May or early June.

In all three of the hydrographs, one of the most telling ordinates is the early April inflow. It appears that this early storm that affected Upper Rainy Creek also affected both the drain flows and the spillway flows. As shown in the reservoir level hydrograph in Figure 8 above, the early runoff only reached the same elevation in the reservoir as the late run off yet each rise and fall from inflow and thus reservoir elevation immediately and directly affected the drains. Even starting and stopping the spillway flow seemed to affect drain flows.

The spillway flows and the drain flows were added together to make a total KDID outflow hydrograph. That hydrograph is shown on the same graph as the Upper Rainy Creek inflow hydrograph in Figure 12 below;

Figure 12:



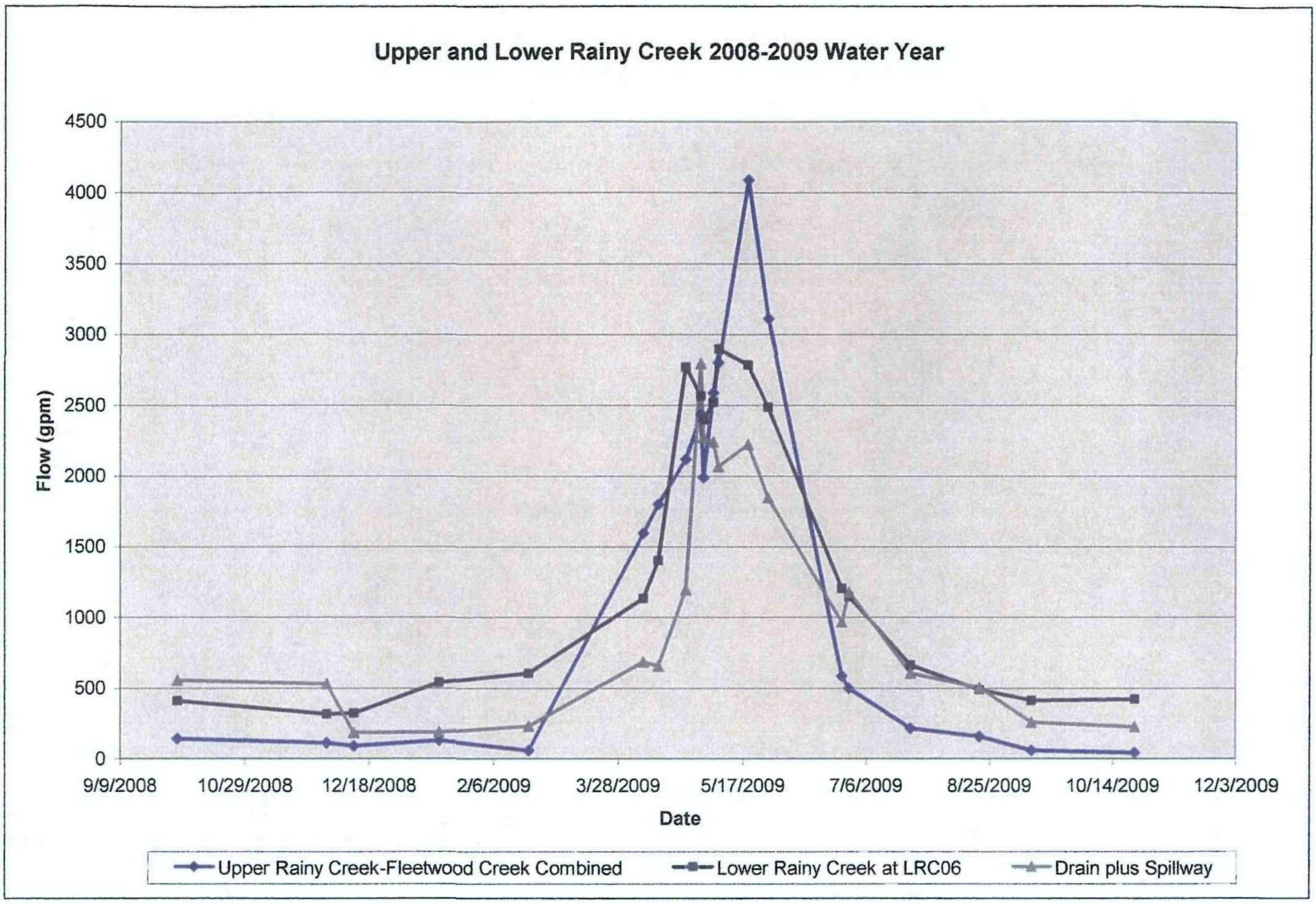
The spike near the early rise in the hydrograph appears to be created the second time the spillway starts to run. It seems that initially the drains are running at capacity for a given reservoir level and then suddenly there is inflow to the reservoir and the spillway starts to run which then adds immediately to the total outflow. As the capacity of the spillway is relatively high for low flow depths, the spillway is able to quickly route inflow which quickly decreases reservoir elevation, so drain flow diminishes, and the total flow drops as well. As shown in Figure11 above, when the spillway stops running there appears to be a slight increase in drain flow and then eventually the drain flows again decline. The changes in the drain flow and spillway flow are not completely understood but it appears that the spillway flows start and stop suddenly so it may be that it takes a certain elevation to start the water flowing in the channel to the spillway but once it starts, it drains the reservoir rather rapidly. This may be indicative of a snow or ice jam, small debris dams or just the height of the grass at the entrance to the spillway channel that suddenly breaches and then drains the reservoir.

What is also apparent from the Figure 12 hydrograph is the routing capacity of the reservoir and water storage in the tailings in the reservoir and in the embankment. The base flow rate and total volume in the drain flow is above the base flow rate and total volume for the Upper Rainy Creek inflow for the majority of the year except during spring runoff. There is 92% of the total volume of water that comes into the reservoir from the first of April to the end of August and the remaining 8% is base flow through the rest of the year. There is 70% of the total volume of water that comes through the drains and the spillway from the first of April to the end of August and the remaining 30% is base flow through the rest of the year. This would indicate that the reservoir, spillway, tailings and embankment storage decreases the peak flow from 4,100 gpm to 1,800 gpm and routes 254 acre-feet (82,800,000 gallons) of water from the peak inflow in May, throughout the rest of the year.

C.1.6. Lower Rainy Creek Outflow: The terminal end of the Rainy Creek drainage basin was measured at the toe of the Rainy Creek valley just above its confluence with the Kootenai River in Lower Rainy Creek 06 (LRC06), a 1 foot Parshall flume. The peak flow rate at LRC06 was 2,900 gpm (6.4 cfs) and the total volume of water leaving the rainy Creek drainage in 2008-2009 was found to be 1,519 acre-feet (495,0129,000 gallons) which includes a net increase in basin yielded from the upper basin to the lower basin of 365 acre-feet of water. The increase is attributed to two drainages that flow into Rainy Creek below the KDID; Carney Creek above LRC02 and an unnamed tributary on the right side of the basin above LRC06. Carney Creek contributed 280 acre-feet of water in 2008-2009 leaving 85 acre-feet. It is assumed that at least 60 acre-feet was contributed from the unnamed tributary leaving approximately 25 acre-feet unaccounted for. It may be that this is the groundwater flow from the upper basin or, as the 25 acre-feet represents 2.0% of the total outflow, it may also be partially attributed to measurement errors.

A hydrograph of the total flow leaving the basin at LRC06 is superimposed on the hydrograph for the Upper Rainy Creek at URC02 and the total amount of drain flow plus spillway flow leaving the KDID in Figure 13 below. As can be seen the inflow hydrograph has a much sharper peak which is then attenuated by the reservoir routing, spillway flow and groundwater flow through the embankment. The drain plus spillway and Lower Rainy Creek at LRC06 hydrographs have a similar shape and similar timing at the peak discharge. The differences between the two Lower Rainy Creek hydrographs are caused by the addition of Carney Creek and the other intermittent stream between LRC02 and LRC06. It is interesting to note that the peak discharge below the KDID and at LRC06 actually occurred before the time of the peak inflow in the Upper Rainy Creek drainage. This is attributed to the sudden rise in the total outflow when the spillway first started to run as well as run off occurring earlier lower down in the drainage basin. The data in this graph shows, once again, the almost immediate reaction that the drain flows have to inflows and the attenuation caused by reservoir routing and embankment flow.

Figure 13:



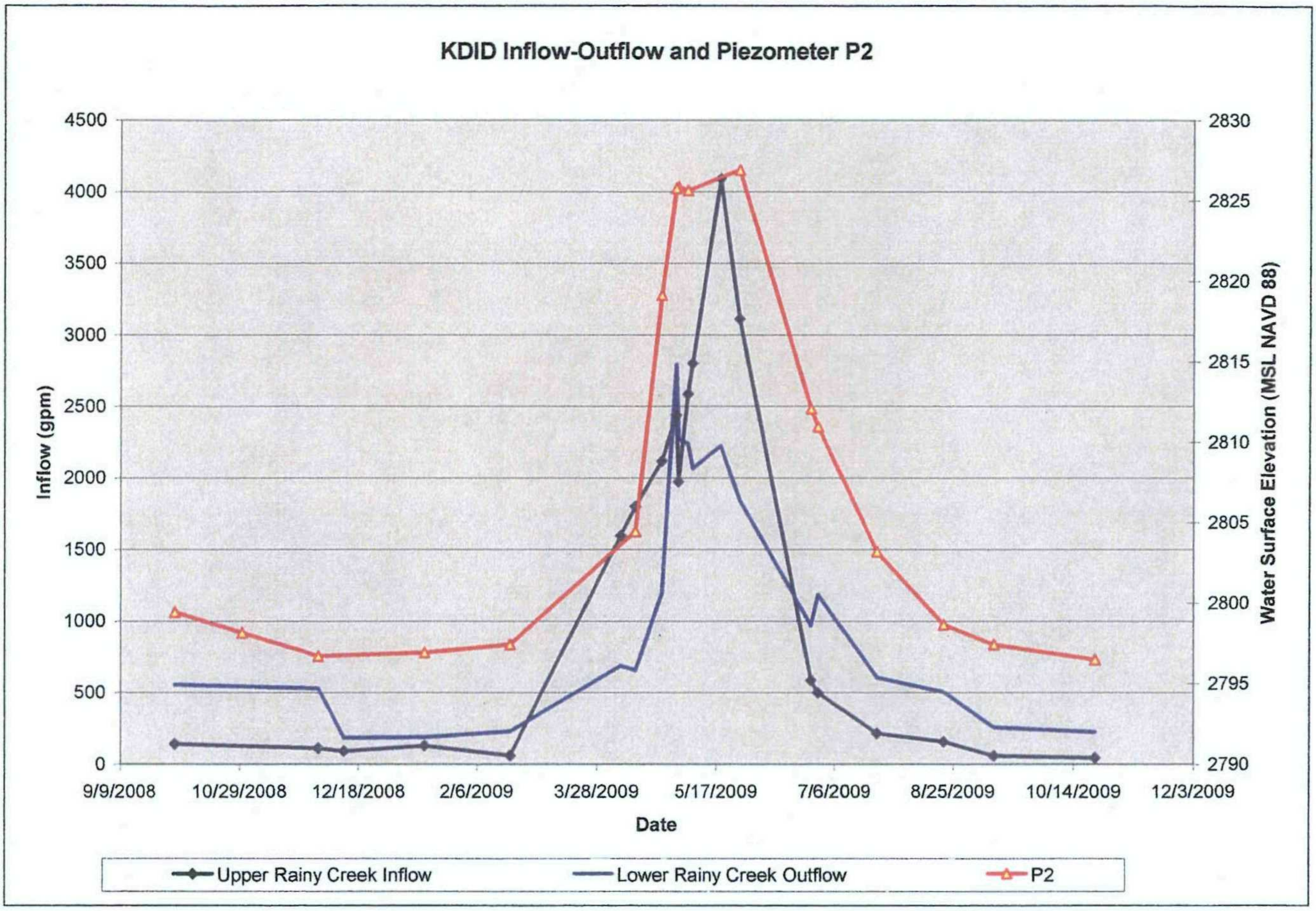
C.2. Piezometer Monitoring Results

Of the fourteen (14) piezometers in the KDID monitoring system, one, P-O, is not monitored and only four (4) had active water surfaces during the monitoring period; piezometers P2, PM1, PM2, and A8. In general, the lowest water surface elevation occurred in late December and the highest water surface elevation occurred in early May. Piezometers P2 recorded a water surface change of 30.2 ft, PM1 reported a change of 9.4 ft., PM2 reported a change of 16.6 ft and A8 reported a change of 5.7 ft. from the lowest to the highest phreatic water elevation in the monitoring period.

The data used for this analysis is for the only active piezometer locations; P2, PM2, PM1, and A8. All data gathered from these piezometers is provided in Appendix D. Data is available for all piezometers from June 2002 to Sept 2009, although only comparisons to inflow and outflow are made to the 2008 - 2009 data to coincide with the only reservoir level and stream flow data available. Additional continuous data was also recorded in piezometers A8 and P2 with two Solinst® Model 3001 Levelogger pressure transducers that were placed down the piezometer ports to actively monitor static water level fluctuations.

The static water level in the piezometers changes steadily as stream flow from Rainy Creek and reservoir elevation fluctuate from early spring through late summer. Static water level at each piezometer location was observed to remain consistently low during the fall and winter months. A plot of the phreatic water surface in piezometer P2, the most active piezometer, is shown superimposed on the inflows from Upper Rainy Creek and the outflows from the KDID drains and spillway flows in Figure 14 below.

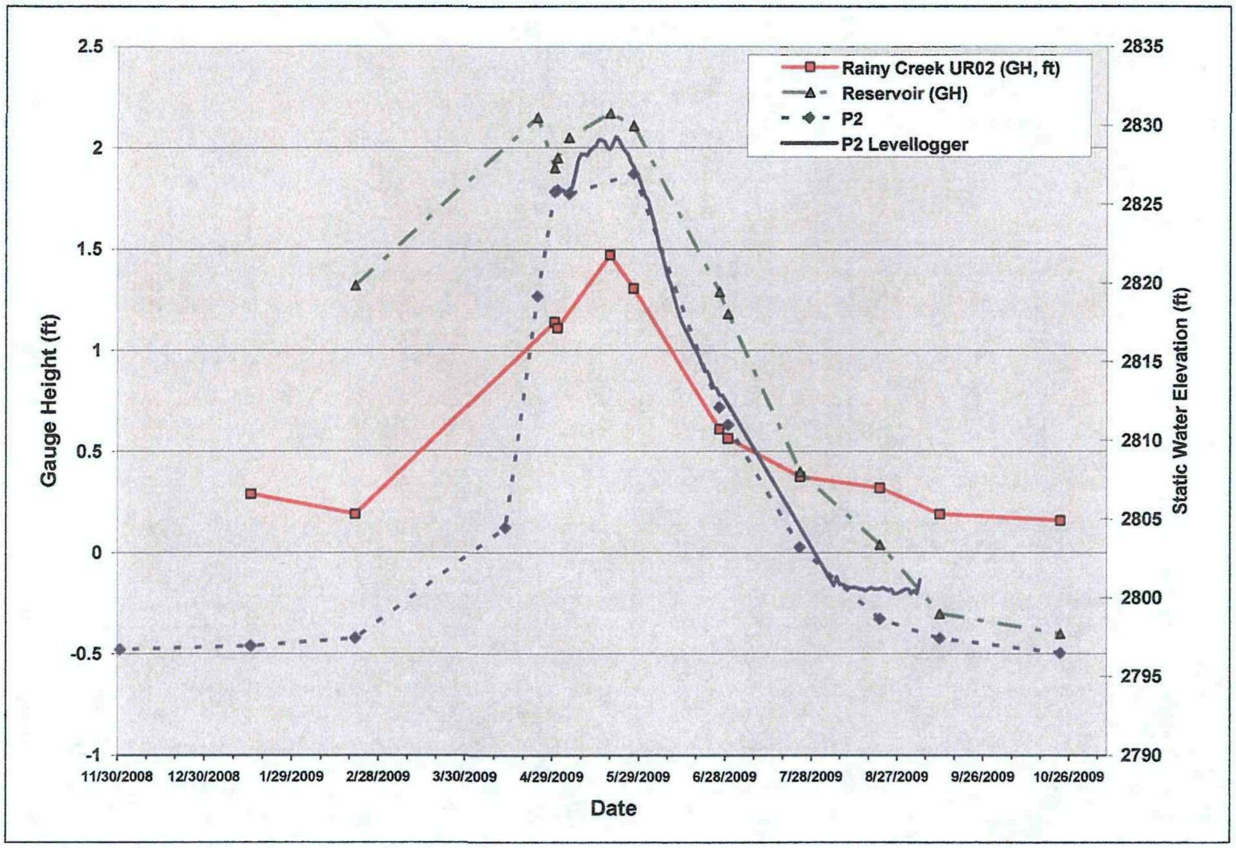
Figure 14:



The graph shows that piezometer, P2, reacts similar to the inflow hydrograph but the changes are not as instantaneous and the phreatic surface rises earlier than the inflow and falls later than the outflow. The piezometers rise but do not seem to be affected by the same early peak that the drains exhibit, and then appear to gain elevation slowly near the peak inflow, rising to the final elevation on May 27th, 2009 12 days after the peak of the inflow. The phreatic water surface elevation starts to fall sharply after the peak of the inflow passes and continually decreases without any noticeable changes when the spillways starts or stops.

As it is known that reservoir levels affect phreatic water surface levels, the data from the reservoir levels was also collected during the 2008-2009 water year. A plot of the inflow hydrograph, the reservoir levels and the phreatic water surface in piezometer P2 is shown in Figure 15 below. Also shown on this graph are the phreatic water surface elevations recorded by the Solinst transducer placed in the piezometer P2 from May to late September. As can be seen the Solinst piezometer readings generally follows the same rise and fall as was recorded by the well probe as well as the rise and fall of the reservoir and the rise and fall of the inflow hydrograph. This graph shows that the periodic monthly measurements are nearly as accurate as the ten-minute interval readings from the transducer.

Figure 15:
Piezometer P2 vs. Gauged Inflow from Rainy Creek & Reservoir Level



The timing of the rise in the static water level in P2 follows closely with rises in reservoir elevation at almost the same time as the rise in stream flow from Rainy Creek. The peak of the inflow was measured 5 days ahead of the peak in the phreatic water surface in P2. It is noted that the static water level in P2 changed approximately 31 feet in the piezometer casing from mid March to mid May and decreased 30 ft. from late May to late August. The rapid rise in P2 and close proximity of the peak is assumed to occur because P2 is the closest piezometer to the reservoir and is on the upstream side of the embankment. Assuming the water in the reservoir travels approximately 1,000 ft. from the bottom of the reservoir to the piezometer, the hydraulic conductivity (K) through the tailings in the impoundment would be approximately 200 ft/day. These K values are considered "...pervious aquifers of well sorted sand or well sorted sand and gravel..."[3]

The same data is presented for piezometer A8 in Figure 16 below.

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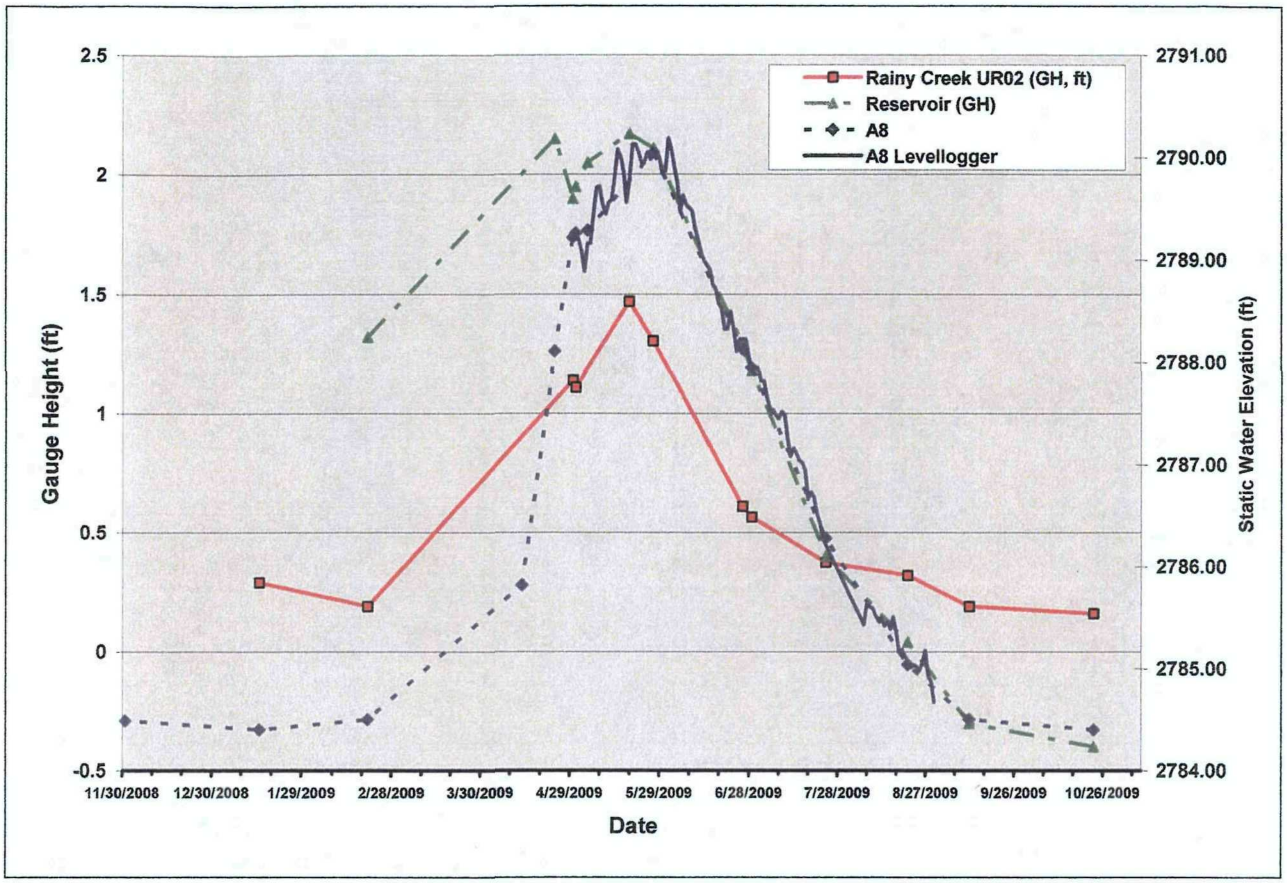
[3] http://en.wikipedia.org/wiki/Hydraulic_conductivity Source: modified from Bear, 1972.

Figure 16: Piezometer A8 vs. Gauged Inflow from Rainy Creek & Reservoir Level



This graph shows that the static water elevation exhibits a similar trend to that of P2 in that it mimics the same rise and fall of the reservoir. However, A8 does have a greater time lag in the peak static water elevation compared to the peak inflow and peak reservoir elevation. Data shows that the peak in A8 occurred 20 days after the peak P2. Assuming that there is roughly 400 ft. of path length from piezometer P2 to piezometer A8, the hydraulic conductivity (K) through the embankment was calculated to be 0.0375 ft/day. Typical K values in this range are "...values for a semi-porous aquifer with poor conductivity, composed of fine sand, silt and loess..."[4]

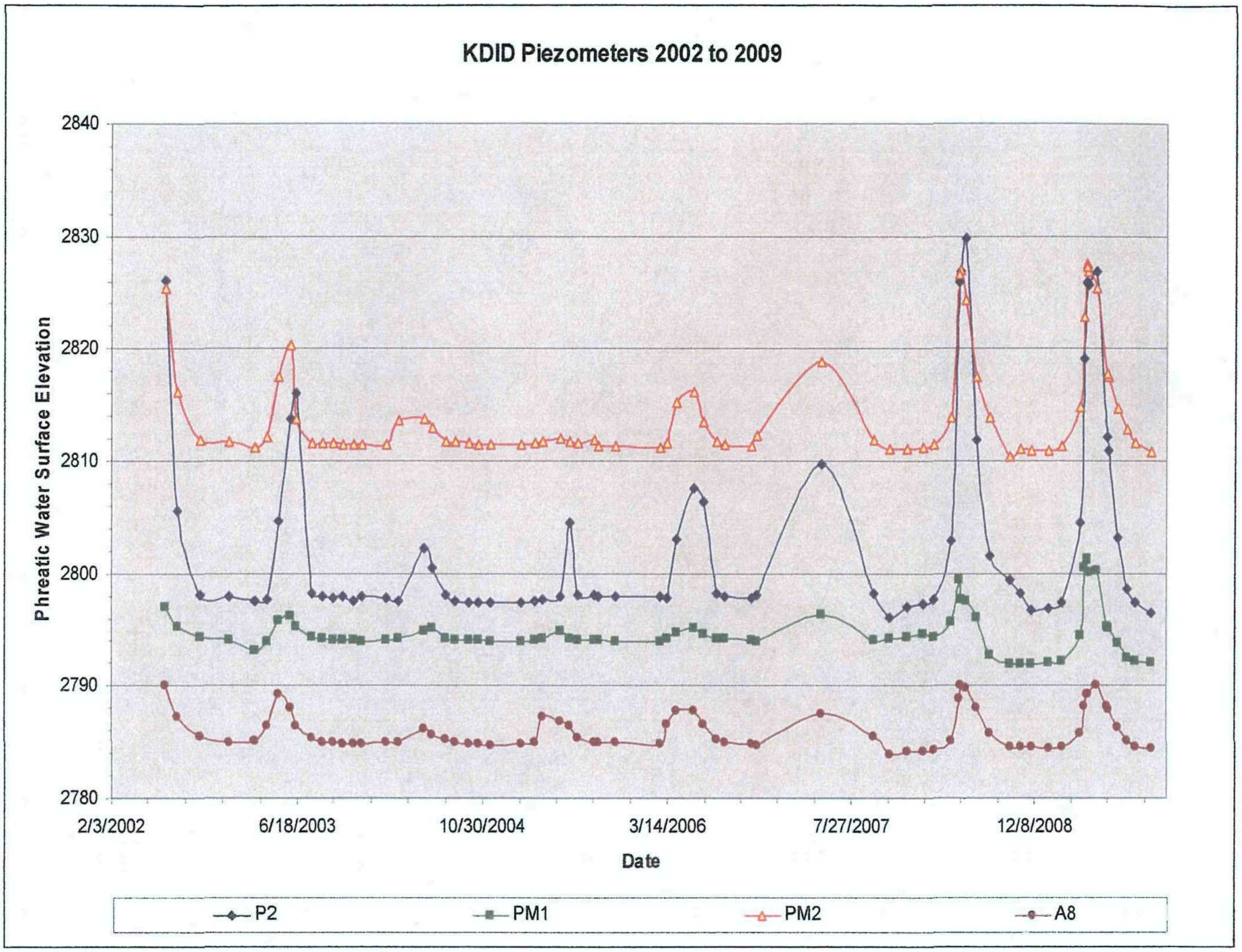
Static water level changes in A8 are far less pronounced, only changing approximately 5.8 feet. As can be seen the Solinst piezometer readings generally follows the same rise and fall as was recorded by the well probe as well as the rise and fall of the reservoir and the rise and fall of the inflow hydrograph which shows that the periodic monthly measurements are nearly as accurate as the ten-minute interval readings in A8.

As discussed above, piezometer data has been gathered seasonally by others from approximately late June in 2002 until May of 2007 and monthly since May of 2007. A

[4] Ibid: Source: modified from Bear, 1972

graph of the phreatic water surface in the active piezometers P2, PM1, PM2 and A8 from 2002 to 2009 is shown in Figure 17 below.

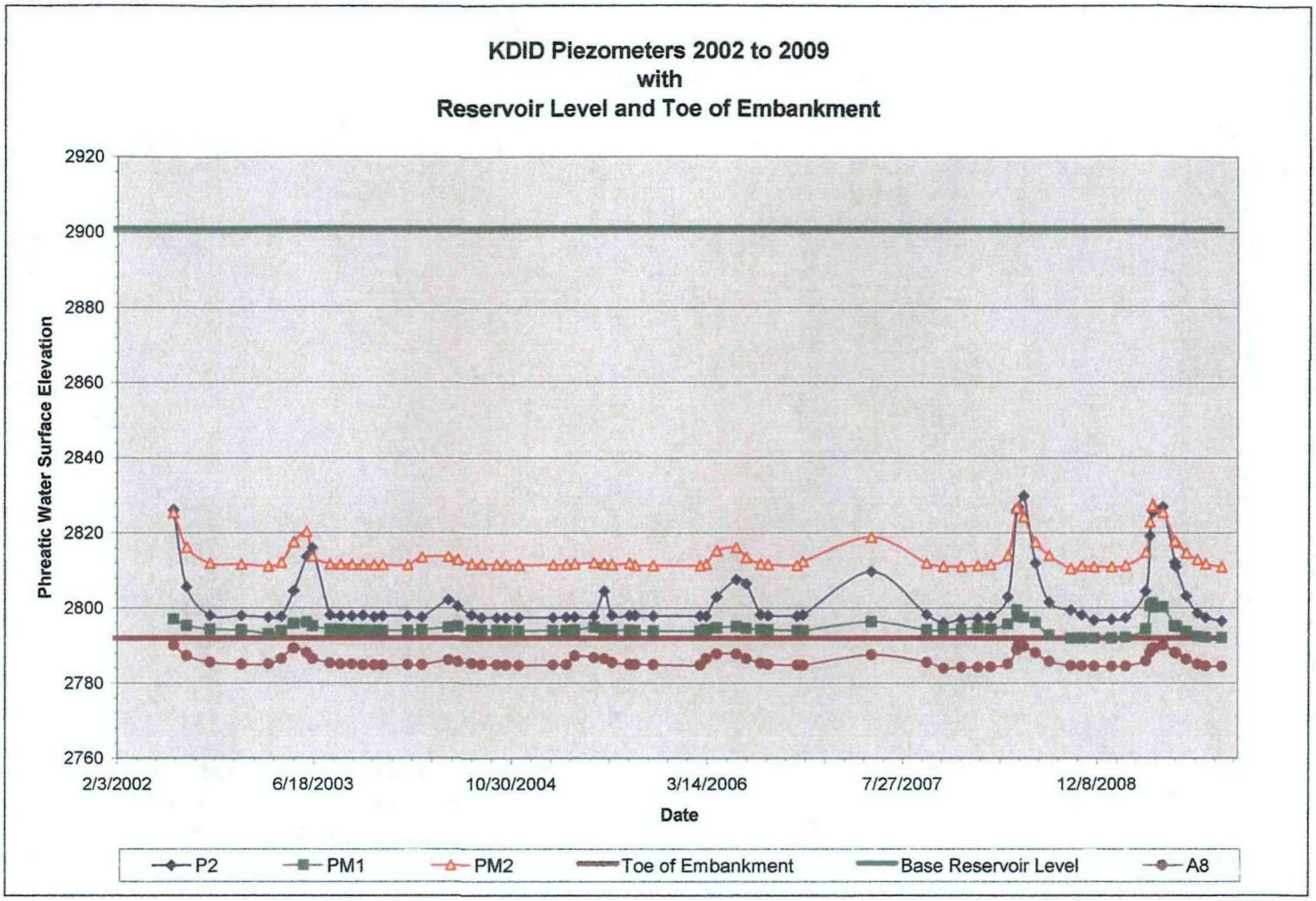
Figure 17:



As can be seen, all of the active piezometers react to the normal season patterns of inflow to the reservoir and the peak elevations change from year to year which is assumed to be based on the order and magnitude of the inflow and reservoir levels.

The piezometers P2 and PM2 have consistently shown the sharpest rise in phreatic water surface and both appear to rise to nearly the same peak elevation each year. Both of these piezometers are near the center line of the embankment and are generally located over the top of Drain 6 which appears to be the central "toe drain" discussed above. Although the drains will change as much as 30 -40 ft. in a year, it is important to note that peak water surface elevation is still 71 ft. below the elevation of the upstream face of the dam where the tailings meet the toe of the embankment . A plot of the piezometers from 2002 to 2009 showing the variation in phreatic surface compared to the elevations of the toe of the embankment and reservoir is shown in Figure 18 below.

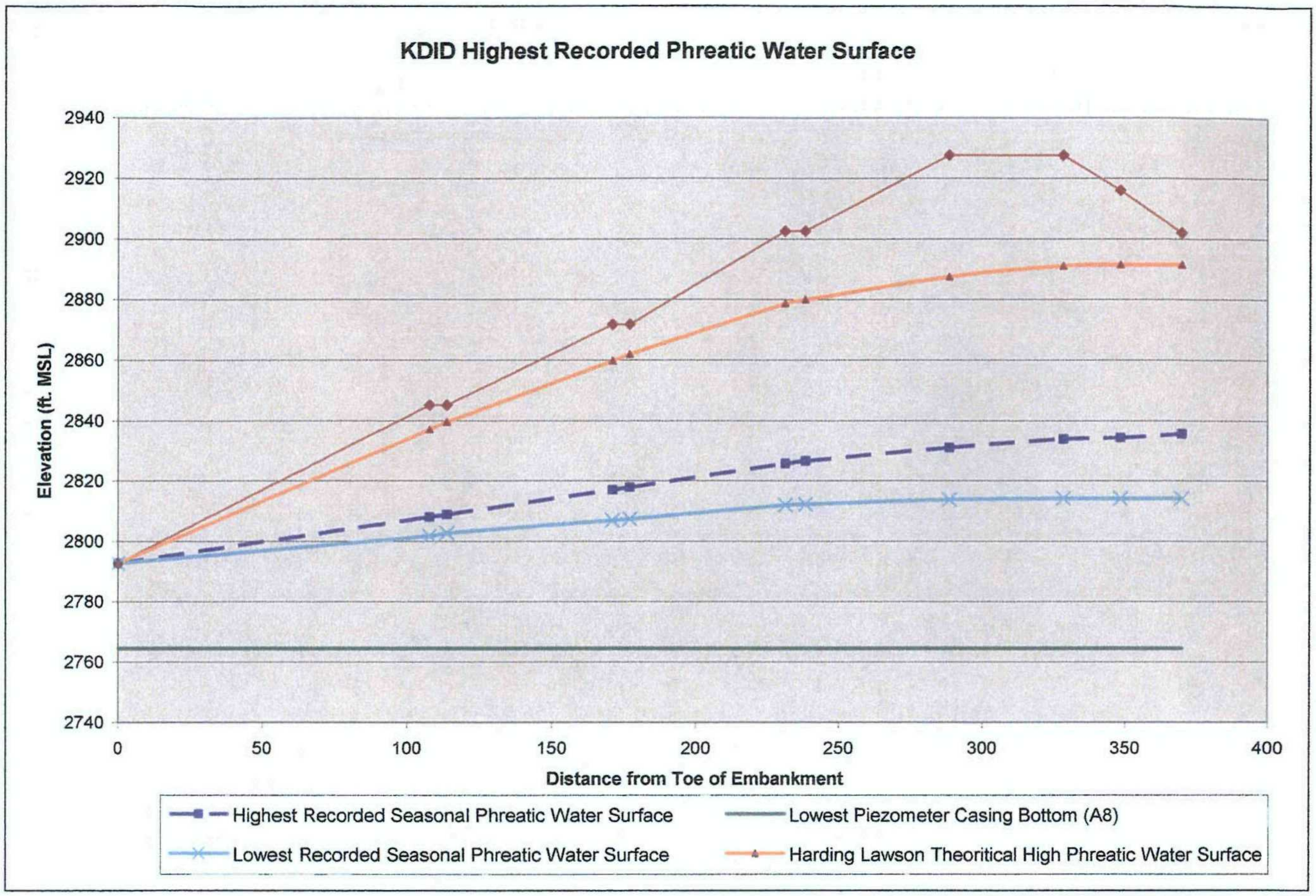
Figure 18:



Shown in Figure 19 below is a plot of the highest and lowest phreatic water surface in piezometer P2 which is on the upstream face of the embankment. The phreatic water surface is plotted through each of the other active piezometers until it exits at the toe of the embankment.

As can be seen, the highest phreatic water surface elevation measure in piezomter P2 is still well below the highest theoretical water surface used to do the original stability analysis on the KDID embankment. As can also be seen, although it has been shown that piezometer P2 changes as much as 30 ft. to 40 ft. each year, this is still within a narrow band of elevations within the embankment. The elevations of the embankment and the elevations of the phreatic water surface are reflective of the actual elevations to within ±0.1 ft. as established in the BHI May 2009 elevation survey and are therefore correctly scaled. The distances shown are scaled from plans and topographic maps and were checked from scaled aerials but are likely within ±10 ft.

Figure 19:



KDID Highest Recorded Phreatic Water Surface
2940
2920
2900
2880
2860
2840
2820
2800
2780
2760
2740
Elevation (ft. MSL)
0
50
100
150
200
250
300
350
400
Distance from Toe of Embankment
Highest Recorded Seasonal Phreatic Water Surface
Lowest Piezometer Casing Bottom (A8)
Lowest Recorded Seasonal Phreatic Water Surface
Harding Lawson Theoritical High Phreatic Water Surface

D. CONCLUSIONS

As shown in this report, from Oct. 2, 2008 to October 23, 2009, 1,154 acre-feet of water flowed into the KDID reservoir. Of that amount, 1,020 acre-feet or 88% of the water infiltrated through the KDID reservoir tailings and flowed into the embankment and discharged through one of twelve drains at the dam toe. Only 10% went over the spillway and 2% was lost to groundwater recharge. As shown by the piezometer plots in Figure 17 and Figure 18 above, this trend appears to occur each year.

Lacking a means to currently cut off drain flow or bypass inflow, the entire stability of the KDID will depend on the ability of the drains to discharge the water that infiltrates the reservoir and upstream face of the embankment. Therefore the safety of the KDID will depend solely on making sure that there is always full drain flow capacity. The phreatic surface is the most critical data used in determining the drain capacity and the subsequent stability of the dam. Currently, the maximum phreatic water surface is well below the theoretical maximum water surface, the drains appear to be functional adequately, and the stability of the dam is not a concern. The drains collect and dispose of seep water safely and there is no appearance that structural material is transported out of the dam.

None the less, piezometer data indicates that the reservoir water is not cut off from the upstream face of the embankment and that the inflow to the reservoir has an immediate effect on the drain flow and a direct but slightly delayed affect on the phreatic water surface elevation beneath the KDID. In all cases, an increase in inflows from Upper Rainy Creek is immediately followed by the subsequent rise in reservoir and increased flow rates from the toe drains. There is a very short, if any, lag time between reservoir rise and rise in the drain outflow. There is a short lag time between the phreatic water surface rise in piezometers such as P2 at the upstream face and a longer lag time to the lowest piezometer, A8 at the toe.

Because the only active piezometers are along the centerline of the embankment and the piezometers on the outsides remain relatively dry, it is assumed that majority of the flow must be being intercepted by the main "Toe Drain" shown on the Phase 1 cross section in Appendix E which is assumed to be Drain 6. This is apparently the reason that Drain 6 is consistently the largest producer for drain flow. It is not know if the other drains receive water from Drain 6 or collect water from the embankment, or both.

It is not known if the maximum capacity of the drains is currently limited. The maximum capacity of the drains that has been recorded is around 1,800 gpm in both 2008 and 2009, but it has not been tracked in any other years so it is not certain if this maximum discharge of the drains or the maximum for a given reservoir elevation. It is certain that the maximum drain flow is directly linked to the maximum head in the reservoir which is generally controlled by the spillway. It appears that the base flow from the drains is between 200 gpm to 400 gpm at the time the phreatic water surface is near the lowest point.

As the inflow has been shown to have a direct affect to the drain flow, if the capacity of the drains was unlimited, it is assumed that the drains would be able to keep up with the increased inflow and we would see very little to no rise in the phreatic water surface and a much longer lag time from upstream to downstream piezometer rises; and we might never see the spillway run. It is assumed there is a limit to the drain capacity.

E. RECOMMENDATIONS

E.1 Records: As there is no means to cut off drain flow and control the phreatic water surface, the only means to judge the existing and long term affect of the phreatic water surface is the performance of the drain system and their affect on the piezometers. The only way to get reliable and useful data is to continue to monitor all of the measurement sites established for this study. As long as each of the measurements are taken monthly, the performance of the drains will be able to be judged on a regular basis and the significance of any changes, such as inflow, will be known after each site visit. The monitoring will also be able to judge if there are any sudden or unexpected changes in the drain system, such as after earth quakes, indicated by rises in phreatic water surface, unexpected rises or falls in drain flows, or the sudden appearance of dirt or other material in the drain outflow. The system will not be able to always predict catastrophic failures before they happen but it will be able to tell if they have happened. Historic data will be able to be used in predicting when the long term performance starts to change and allow for sufficient time to prepare repairs or rehabilitation.

It will be important that the on-site personnel are familiar with past performance of the drain system and are able to recognize changes or anomalies in the drain flows. There should be at least two full sets of records maintained each year; one with the engineer of record and one at the dam site. There is a sufficient amount of records and institutional knowledge that has been established from the once a month visits that on site personnel familiar with the project will be able to compare on site measured conditions to past conditions and make reasonable predictions about the performance if there is an unusual observation. Therefore, currently the only means to judge the on-site performance of the drains will be to be able to compare them to past records.

The records should be easily accessible to any other personnel that access the KDID area and there should be notice given to any on site personnel that any anomalies in the drain flow such as dirty or stained water, sudden increases or decrease in drain flow, the appearance of water at the ground surface at the toe of the embankment or on the face of the embankment, should be brought to the attention of the engineer of record as soon as possible.

There is currently no way to know how the drains are performing other than piezometer readings during on site observations. Eventually, if the active piezometers and possibly drain flows could be monitored with transducers those transducers could be wired to a transmitter sending out real time data. Real time piezometer and drain data would provide the best opportunity to have real time records and real time warnings when changes in these readings indicate problems.

E.1.1. It is recommended that a copy of the KDID Operation and Maintenance (O&M) manual be kept on site and that the yearly inflow, drain flow and spillway flow records and hydrographs be available for comparison. A copy of forms used to report unusual occurrences should be kept with the O&M manual and on site personnel should be aware of the forms and contact numbers in the manual.

E.2. Surface Water Monitoring: The KDID surface water monitoring system was only established for a single season. The stream gauge and flow measurement data collected was extensive and the measuring devices were varied as they were from several different programs that have been conducted on the site over the last three years. The URC02 and LRC01 flumes are in good condition but they need to be continually maintained to keep the water from going under or around the flumes. There is not enough data to be able to predict inflow and outflow trends none the less the data is valuable in that it can both monitor existing flow data as well as be used to compare trends from year to year. . There is still no permanent measurement for Fleetwood Creek.

E.2.1: It is recommended that the existing flumes be monitored and maintained and that a 2 ft. H-Flume be installed in Fleetwood Creek above Rainy Creek.

E.3. Piezometers: The piezometers have been recently repaired at the surface and provide reliable and easy to read data collection. The location of the piezometers accurately reflects the active phreatic water surface zone and the number of piezometers is sufficient to be able to track current phreatic water surface levels, compare previous year's data, and to predict future and normal maximum phreatic water surfaces.

E.31.: The maximum water surface elevation should be recorded on the top or inside of the piezometer casing to be used as an immediate reference check if necessary. In addition, the maximum allowable phreatic water surface should be estimated and noted on the piezometer cap as well.

E.3.1.a.: Eventually it is recommended that permanent transducers be installed in piezometers P2 and A8 and that the transducers should be wired to the surface to allow for ease of readings without removing the transducers each time and disturbing the long term record if the piezometers wired to the surface could be sent to a transmitter to be able to be read remotely.

E.4. Drain Flow Monitoring: The drain flow monitoring flumes and weirs have been established since the fall of 2007 and various flumes and weirs have been added since. There are certainly more flumes or better measurement locations that could be selected and eventually it would be preferred to have a measuring device on each drain. None the less, the number and location of the current weirs and flumes below the drains is sufficient to track current flows and compare past flows. There is not enough data to date to be able to predict future trends in drain flows.

E.4.1.: It is recommended that the existing flumes and weirs continue to be maintained and improved when necessary.

E.4.1.a.: Eventually it is recommended that a permanent transducer be installed in the LRC01 flume to help preserve and improve the reliability of the long term record.

E.5. Spillway Monitoring: Spillway flows are only monitored when water is visually seen running in the spillway. Given the anomalies that appear in the drain flows when the spillway starts and stops running, it is apparent that a more reliable means of tracking spillway flow is needed.

E.5.1.: It is recommended that a permanent staff gauge be mounted in the spillway to make a more reliable flow measurement.

E.5.1.a.: Eventually it is recommended that a piezometer tube be installed adjacent to the spillway and that a transducer be placed in the piezometer and monitored for at least one if not two seasons. The spillway flows should be monitored in conjunction with drains 1 & 2 to see if there is any validity to the timing of the spillway flows and the timing of the drain flows in drains 1 & 2.

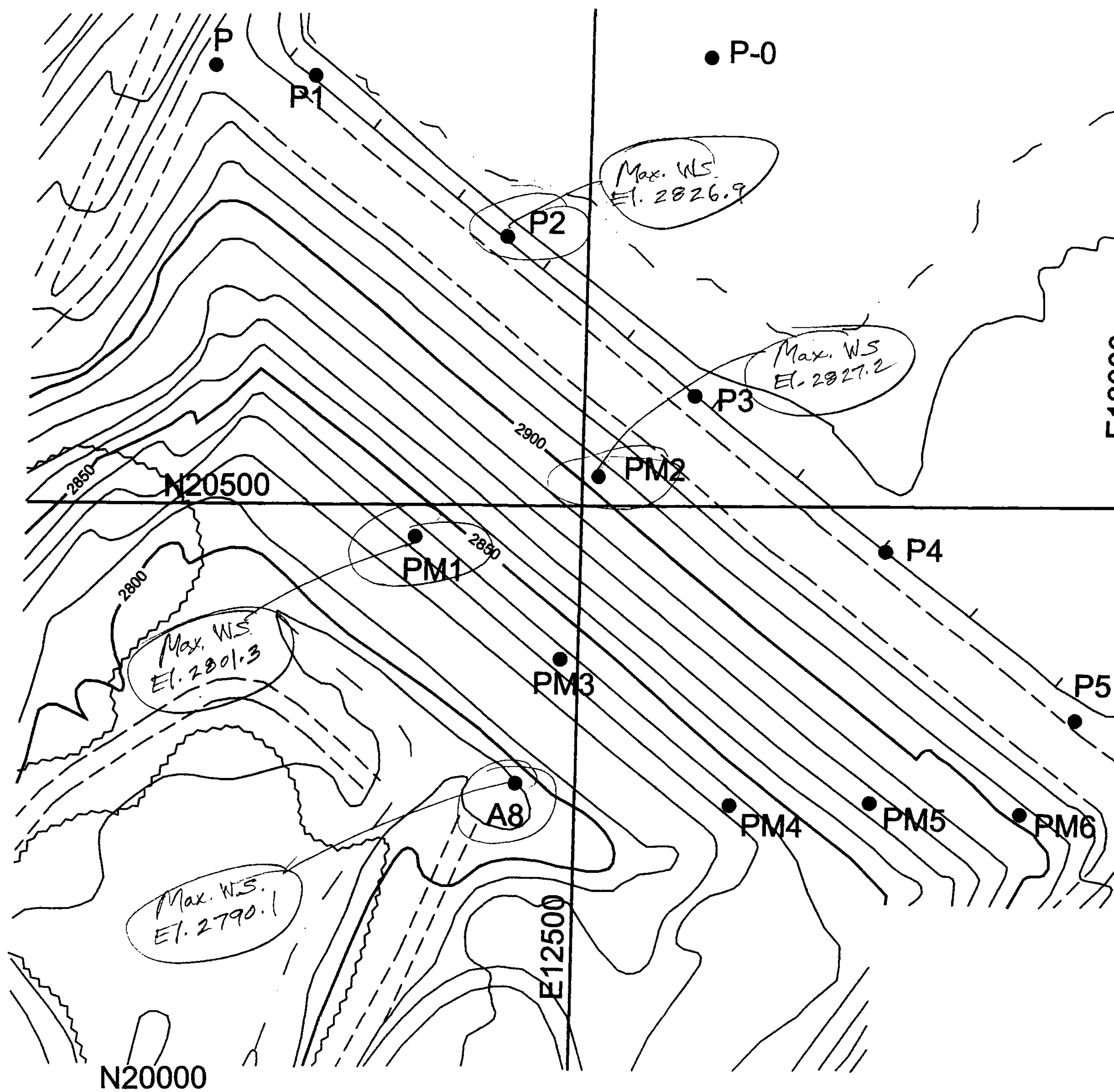
E.6 Monitoring Duties: In order to maintain an accurate monitoring program the following is a list of recommended activities that should be completed at each monthly inspection. In addition, any repairs needed to preserve or improve the accuracy of a particular device is also listed. Lastly, any upgrades that would improve the accuracy, reliability or response time is also listed;

1. Measure the gauge height in URC02 and convert to flow rate
    a. Record flows and track total volume
        i. Repair the upstream cut off so all water goes through the flume
        ii. Check the flume each spring to assure that ice or high spring flows has not moved or displaced the flume
2. Record the reservoir staff gauge height and convert to elevation and volume
3. Record each of the piezometer water surface elevations
    a. Convert to elevation data
    b. Plot in Excel, compare to previous years
4. Record any spillway flow
    a. Record flows and track total volume
        i. Establish and read a permanent staff gauge in the spillway
5. Record the flow from each drain
    a. Note the total amount of flow from each drain by observation or measurement
    b. Record temperature
    c. Note if the flow is clear
6. Measure the gauge height in LRC01 and convert to flow rate
    a. Record flows and track total volume
7. Measure the gauge height in CC02, LRC02 and LRC06 and convert to flow rate and annual volume

E.6. DNRC Conditions: .As discussed above, the DNRC is currently requiring that the exact location of the terminal ends of the drains needs to be mapped and a plan for cleaning and maintaining the drains must be developed prior to April 15th, 2010 and that the drains must be cleaned and maintained prior to December 31, 2010. The outlet end of the drains were cleaned in December of 2008 and, other than drain 7, they are currently free flowing. Tools have been constructed to allow for manual cleaning when necessary.

In order to map the location of the terminal ends of the drains, BHI has purchased a sled mounted video camera capable of viewing and recording the first 100 ft. of the drains into the embankment. After review of the Phase 1 toe drain plan it was felt that there may not be any way to go any further than the cross drains located approximately 75 ft. from the toe of the embankment. In Drain 6 it appears that the drop structure will limit inspection beyond about 200 ft., although the depth of water in the drain may limit inspection to less than that length. Therefore the initial investment by BHI was in a camera sled capable of traveling 100 ft. Once the initial 100 ft. of the drains is investigated and videotaped, the results will be reviewed and a plan developed for any required maintenance. If it is possible to extend the inspection further into the embankment, and it is recommended to do so by the DNRC Dam Safety program, the means to that will need to be determined. The initial investigation of the terminal ends of the drains is currently planned for the last week in February of 2010.

E.7. Long Term Goals: It is recommended that the feasibility of cutting off the drain flow, breeching the reservoir, by-passing the reservoir or a combination of any or all or any other feasible means of decommissioning the KDID should continue to be investigated. It is noted that the average life cycle of most engineered systems in dams is designed to have a life cycle of between 25 and 50 years. Certainly some components such as the CMP toe drains 5 and 8 have already have life cycle concerns. Although it is not unexpected that a concrete structure or embankment dam itself, if maintained, might have a life cycle between 50 and 100 years, it is reasonable to assume that most of the infrastructure in the KDID has a maximum 50 year life cycle. As the existing structure has been in place since at least the early 1980s the current age is between 25 and 30 years old. It is not unreasonable to assume that some time before the next 20 to 25 years pass, major rehabilitation of the KDID drains could be anticipated and it is recommended that contingency plans for repair, replacement rehabilitation or decommissioning should be prepared before than time.



NORTH

PIEZOMETER LOCATIONS

SCALE : 1" = 60'

REVISIONS | DATE: | DESCRIPTION: | BY

DRAWN BY: TDL | APPROVED BY: J J B

PIEZOMETER LOCATIONS

FOR

REMEDIUM GROUP

T. 31N., R. 30W., P.M., M., LINCOLN COUNTY

BILLMAYER & HAFFERMAN, INC.
2191 THIRD AVE. EAST, KALISPELL, MT. 59901 PHONE: (406) 257-8708
FAX: (406) 257-8710
EMAIL: info@billmayer.com
ONLINE: http://www.billmayer.com

DRAWING TITLE:
PIEZOMETER LOCATIONS

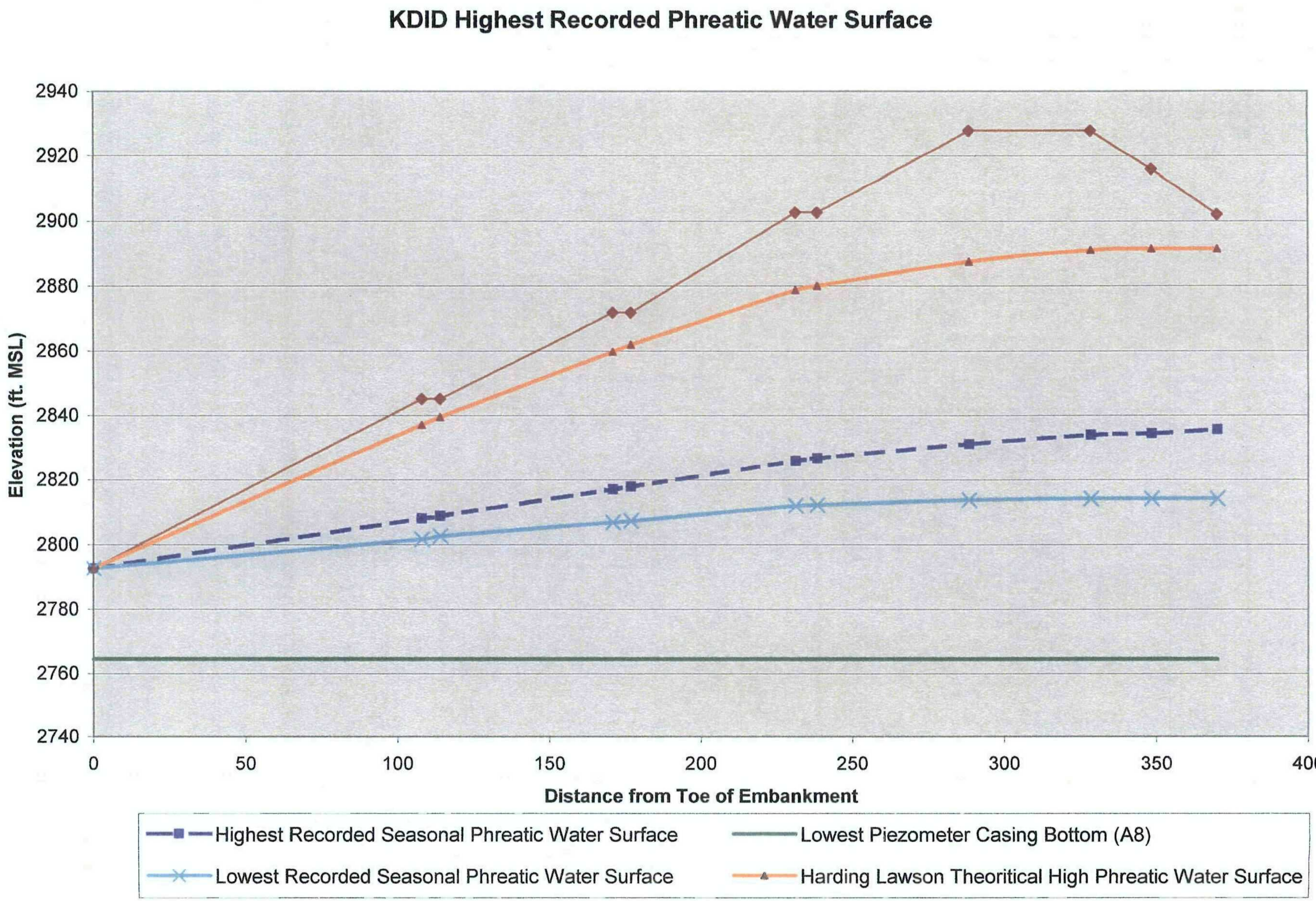
SCALE:
AS SHOWN

DATE:
MAY 15, 2006

PROJECT NO:
R.56.1

DRAWING NUMBER:
1 of 1

R.56.1\dwg\piezometer locations.dwg


KDID Highest Recorded Phreatic Water Surface
Elevation (ft. MSL)
2940
2920
2900
2880
2860
2840
2820
2800
2780
2760
2740
0
50
100
150
200
250
300
350
400
Distance from Toe of Embankment
Highest Recorded Seasonal Phreatic Water Surface
Lowest Piezometer Casing Bottom (A8)
Lowest Recorded Seasonal Phreatic Water Surface
Harding Lawson Theoritical High Phreatic Water Surface

Billmayer Engineering
Kootenai Development Impoundment Dam Annual Inspection
23-Oct-09 Last Update
Hafferman **Bold = interpolated values**
Wet Piezometer Plots

Piezometer Num	P2		Elev.	PM1		Elev.	PM2		Elev.	A8		Elev.
		G.S.=	2917.321		G.S.=	2845.852			2915.04		G.S.=	2792.7
Date	DW	TD	WS Elev	DW	TD	WS Elev	DW	TD	WS Elev	DW	TD	WS Elev
10/23/2009	120.85	122.1	2796.471	53.81	54.8	2792.042	104.22	104.6	2810.82	8.30	28.3	2784.40
9/11/2009	119.91	122.1	2797.411	53.69	54.8	2792.162	103.39	104.6	2811.65	8.2	28.3	2784.50
8/21/2009	118.67	122.1	2798.651	53.42	54.8	2792.432	102.18	104.6	2812.86	7.66	28.3	2785.04
7/24/2009	114.13	122.1	2803.191	52.07	54.8	2793.782	100.41	104.6	2814.63	6.42	28.3	2786.28
6/29/2009	106.36	122.1	2810.961	50.73	54.8	2795.122	97.52	104.6	2817.52	4.75	28.3	2787.95
6/26/2009	105.24	122.1	2812.081	50.6	54.8	2795.252	97.24	104.6	2817.8	4.565	28.3	2788.14
5/27/2009	90.4	122.1	2826.921	45.62	54.8	2800.232	89.6	104.6	2825.44	2.65	28.3	2790.05
5/5/2009	91.68	122.1	2825.641	45.71	54.8	2800.142	88.15	104.6	2826.89	3.41	28.3	2789.29
5/1/2009	91.45	122.1	2825.871	44.56		2801.292	87.52	104.6	2827.52	3.44	28.3	2789.26
4/30/2009	91.55	122.1	2825.771	44.66	54.8	2801.192	87.81	104.6	2827.23	3.48	28.3	2789.22
4/24/2009	98.18	122.1	2819.141	45.37	54.8	2800.482	92.13	104.6	2822.91	4.59	28.3	2788.11
4/13/2009	112.87	122.1	2804.451	51.43	54.8	2794.422	100.24	104.6	2814.8	6.88	28.3	2785.82
2/20/2009	119.9	122.1	2797.421	53.69	54.8	2792.162	103.75	104.6	2811.29	8.2	28.3	2784.50
1/15/2009	120.4	122.1	2796.921	53.86	54.8	2791.992	104.11	104.6	2810.93	8.3	28.3	2784.40
12/1/2008	120.61	122.1	2796.711	53.9	54.8	2791.952	104.07	104.6	2810.97	8.21	28.3	2784.49
10/30/2008	**119.17**	122.1	2798.151	53.87	54.8	2791.982	103.91	104.6	2811.13	8.18	28.3	2784.52
10/2/2008	**117.9**	122.1	2799.421	53.94	54.8	2791.912			2915.04	8.09	28.3	2784.61
8/8/2008	115.78	122.1	2801.541	53.12	54.8	2792.732	101.1	104.6	2813.94	6.97	28.3	2785.73
7/3/2008	105.4	122.1	2811.921	49.73	54.8	2796.122	97.49	104.6	2817.55	4.65	28.3	2788.05
6/3/2008	87.52	122.1	2829.801	48.36	54.8	2797.492	90.71	104.6	2824.33	2.93	28.3	2789.77
5/20/2008	**90.49**	122.1	2826.831	48.17	54.8	2797.682	88	104.6	2827.04	2.67	28.3	2790.03
5/16/2008	91.34	122.1	2825.981	46.45	54.8	2799.402	88.4	104.6	2826.64	3.88	28.3	2788.82
4/23/2008	114.42	122.1	2802.901	50.16	54.8	2795.692	101.1	104.6	2813.94	7.6	28.3	2785.10
3/10/2008	119.65	122.1	2797.671	51.47	54.8	2794.382	103.53	104.6	2811.51	8.4	28.3	2784.30
2/7/2008	**120.1**	122.1	2797.221			2845.852			2915.04	8.55	28.3	2784.15

?

2815?

	P2			PM1			PM2			A8		
Date	DW	TD	WS Elev	DW	TD	WS Elev	DW	TD	WS Elev	DW	TD	WS Elev
12/26/2007	120.34	122.1	2796.981	51.52	54.8	2794.332	103.98	104.6	2811.06	8.52	28.3	2784.18
11/9/2007	121.3	122.1	2796.021	51.65	54.8	2794.202	104	104.6	2811.04	8.75	28.3	2783.95
9/27/2007	119.12	122.1	2798.201	51.75	54.8	2794.102	103.12	104.6	2811.92	7.22	28.3	2785.48
5/8/2007	107.64	122.1	2809.681	49.57	54.8	2796.282	96.18	104.6	2818.86	5.22	28.3	2787.48
11/14/2006	119.21	122.1	2798.111	51.88	54.8	2793.972	102.72	104.6	2812.32	7.96	28.3	2784.74
10/30/2006	119.48	122.1	2797.841	51.82	54.8	2794.032	103.69	104.6	2811.35	7.92	28.3	2784.78
8/16/2006	119.39	122.1	2797.931	51.72	54.8	2794.132	103.51	104.6	2811.53	7.72	28.3	2784.98
7/28/2006	119.14	122.1	2798.181	51.61	54.8	2794.242	103.32	104.6	2811.72	7.42	28.3	2785.28
6/21/2006	110.89	122.1	2806.431	51.23	54.8	2794.622	101.62	104.6	2813.42	6.18	28.3	2786.52
5/27/2006	109.78	122.1	2807.541	50.76	54.8	2795.092	98.92	104.6	2816.12	4.98	28.3	2787.72
4/7/2006	114.34	122.1	2802.981	51.14	54.8	2794.712	99.79	104.6	2815.25	4.96	28.3	2787.74
3/12/2006	119.52	122.1	2797.801	51.62	54.8	2794.232	103.39	104.6	2811.65	6.18	28.3	2786.52
2/24/2006	119.44	122.1	2797.881	51.95	54.8	2793.902	103.79	104.6	2811.25	7.92	28.3	2784.78
10/27/2005	119.41	122.1	2797.911	51.94	54.8	2793.912	103.76	104.6	2811.28	7.81	28.3	2784.89
9/10/2005	119.32	122.1	2798.001	51.84	54.8	2794.012	103.66	104.6	2811.38	7.76	28.3	2784.94
8/27/2005	119.3	122.1	2798.021	51.78	54.8	2794.072	103.14	104.6	2811.9	7.68	28.3	2785.02
7/14/2005	119.22	122.1	2798.101	51.74	54.8	2794.112	103.46	104.6	2811.58	7.28	28.3	2785.42
6/24/2005	112.79	122.1	2804.531	51.68	54.8	2794.172	103.29	104.6	2811.75	6.22	28.3	2786.48
5/29/2005	119.42	122.1	2797.901	50.92	54.8	2794.932	103.01	104.6	2812.03	5.91	28.3	2786.79
4/10/2005	119.7	122.1	2797.621	51.72	54.8	2794.132	103.32	104.6	2811.72	5.42	28.3	2787.28
3/19/2005	119.82	122.1	2797.501	51.82	54.8	2794.032	103.49	104.6	2811.55	7.79	28.3	2784.91
2/13/2005	119.86	122.1	2797.461	51.87	54.8	2793.982	103.54	104.6	2811.5	7.86	28.3	2784.84
11/19/2004	119.9	122.1	2797.421	51.91	54.8	2793.942	103.59	104.6	2811.45	7.96	28.3	2784.74
10/17/2004	119.89	122.1	2797.431	51.84	54.8	2794.012	103.52	104.6	2811.52	7.91	28.3	2784.79
9/24/2004	119.91	122.1	2797.411	51.81	54.8	2794.042	103.49	104.6	2811.55	7.82	28.3	2784.88
8/17/2004	119.84	122.1	2797.481	51.79	54.8	2794.062	103.34	104.6	2811.7	7.79	28.3	2784.91
7/22/2004	119.21	122.1	2798.111	51.72	54.8	2794.132	103.29	104.6	2811.75	7.42	28.3	2785.28
6/18/2004	116.8	122.1	2800.521	50.69	54.8	2795.162	102.14	104.6	2812.9	7.01	28.3	2785.69
5/25/2004	115.14	122.1	2802.181	50.95	54.8	2794.902	101.34	104.6	2813.7	6.55	28.3	2786.15
3/19/2004	119.74	122.1	2797.581	51.68	54.8	2794.172	101.46	104.6	2813.58	7.8	28.3	2784.90
2/12/2004	119.45	122.1	2797.871	51.82	54.8	2794.032	103.52	104.6	2811.52	7.8	28.3	2784.90
12/10/2003	119.44	122.1	2797.881	51.86	54.8	2793.992	103.54	104.6	2811.5	7.91	28.3	2784.79
11/19/2003	119.72	122.1	2797.601	51.84	54.8	2794.012	103.59	104.6	2811.45	7.9	28.3	2784.80

Date	DW	TD	WS Elev	DW	TD	WS Elev	DW	TD	WS Elev	DW	TD	WS Elev
10/21/2003	119.32	122.1	2798.001	51.84	54.8	2794.012	103.54	104.6	2811.5	7.94	28.3	2784.76
9/23/2003	119.51	122.1	2797.811	51.76	54.8	2794.092	103.49	104.6	2811.55	7.7	28.3	2785.00
8/26/2003	119.42	122.1	2797.901	51.62	54.8	2794.232	103.42	104.6	2811.62	7.68	28.3	2785.02
7/29/2003	119.16	122.1	2798.161	51.58	54.8	2794.272	103.38	104.6	2811.66	7.39	28.3	2785.31
6/14/2003	101.34	122.1	2815.981	50.62	54.8	2795.232	101.23	104.6	2813.81	6.22	28.3	2786.48
5/30/2003	103.62	122.1	2813.701	49.67	54.8	2796.182	94.67	104.6	2820.37	4.62	28.3	2788.08
4/28/2003	112.74	122.1	2804.581	50.02	54.8	2795.832	97.48	104.6	2817.56	3.41	28.3	2789.29
3/28/2003	119.62	122.1	2797.701	51.99	54.8	2793.862	102.91	104.6	2812.13	6.21	28.3	2786.49
2/24/2003	119.82	122.1	2797.501	52.74	54.8	2793.112	103.9	104.6	2811.14	7.62	28.3	2785.08
12/18/2002	119.34	122.1	2797.981	51.74	54.8	2794.112	103.36	104.6	2811.68	7.77	28.3	2784.93
9/30/2002	119.28	122.1	2798.041	51.55	54.8	2794.302	103.12	104.6	2811.92	7.22	28.3	2785.48
7/31/2002	111.72	122.1	2805.601	50.54	54.8	2795.312	98.87	104.6	2816.17	5.46	28.3	2787.24
6/28/2002	91.22	122.1	2826.101	48.82	54.8	2797.032	89.63	104.6	2825.41	2.62	28.3	2790.08

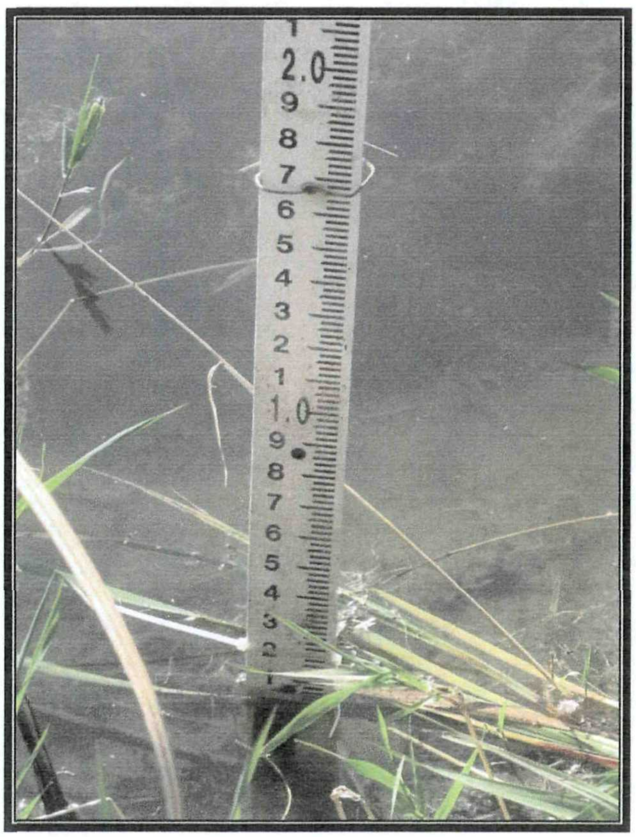
APPENDIX

APPENDIX A

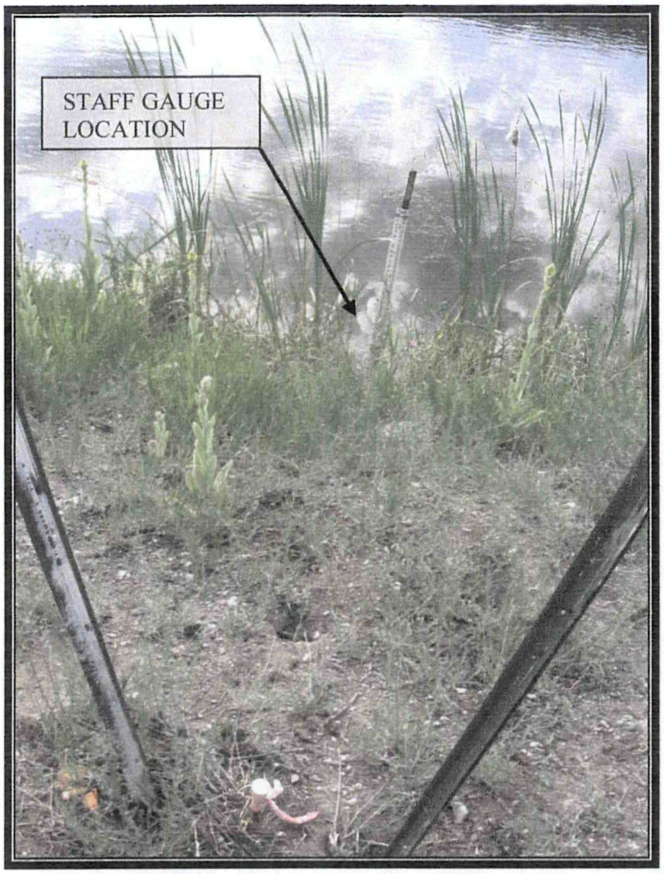
SITE PHOTOGRAPHS

A.1 - Measuring Device Photographs

A.1.1 - Upper Rainy Creek Flume – URC01

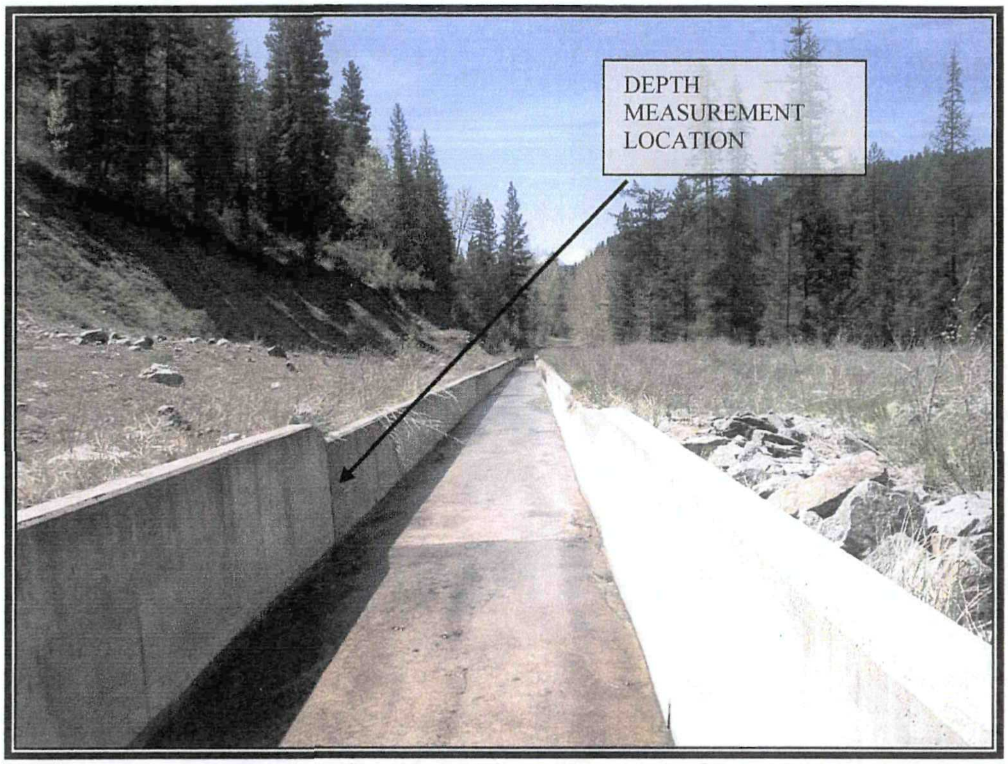


A.1.2. - Reservoir Staff Gauge



A.1.3. - KDID Reservoir Staff Gauge July 24, 2009

A.1.4. - Concrete chute spillway looking back at exit to box culvert

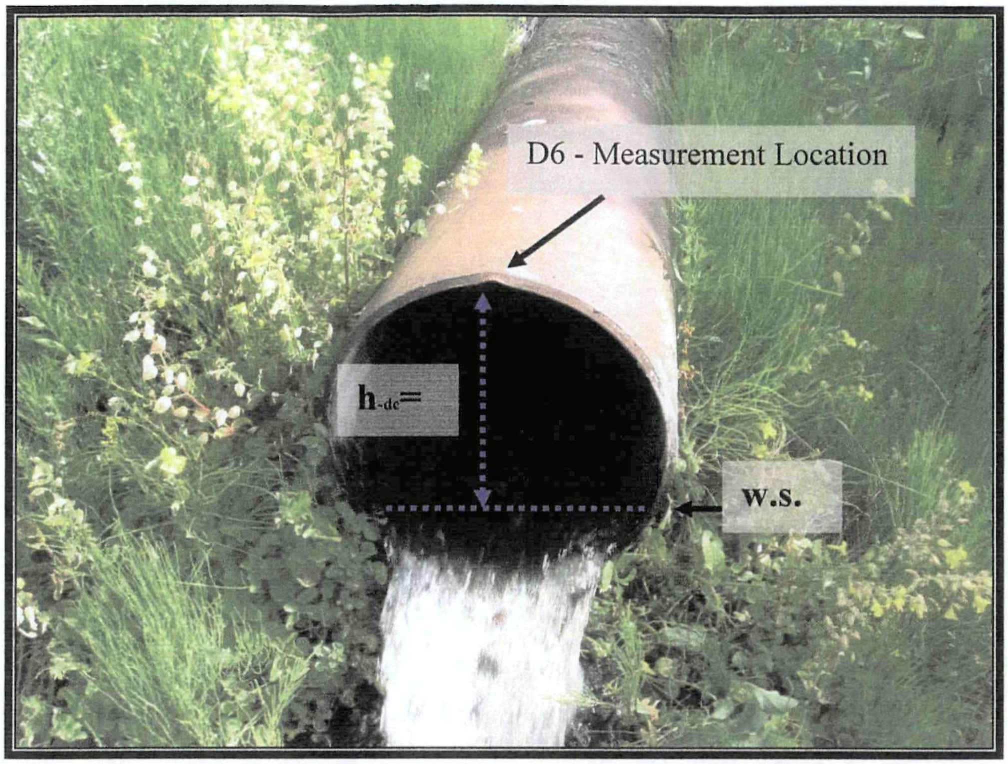


A.1.5. - Concrete chute spillway at exit from box culvert

A.1.6 – 1-ft. rectangular Weir

A.1.7. - H-Flume 1-2-3-4

A.1.8. - V-Notch Weir 5 and Drain 5

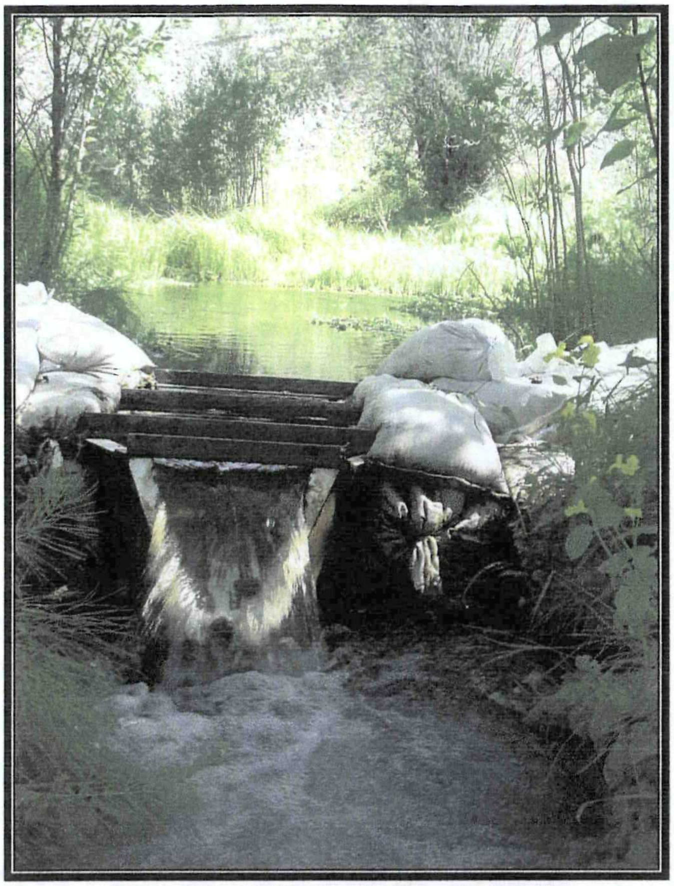


A.1.9. – Drain 6 Measurement Location

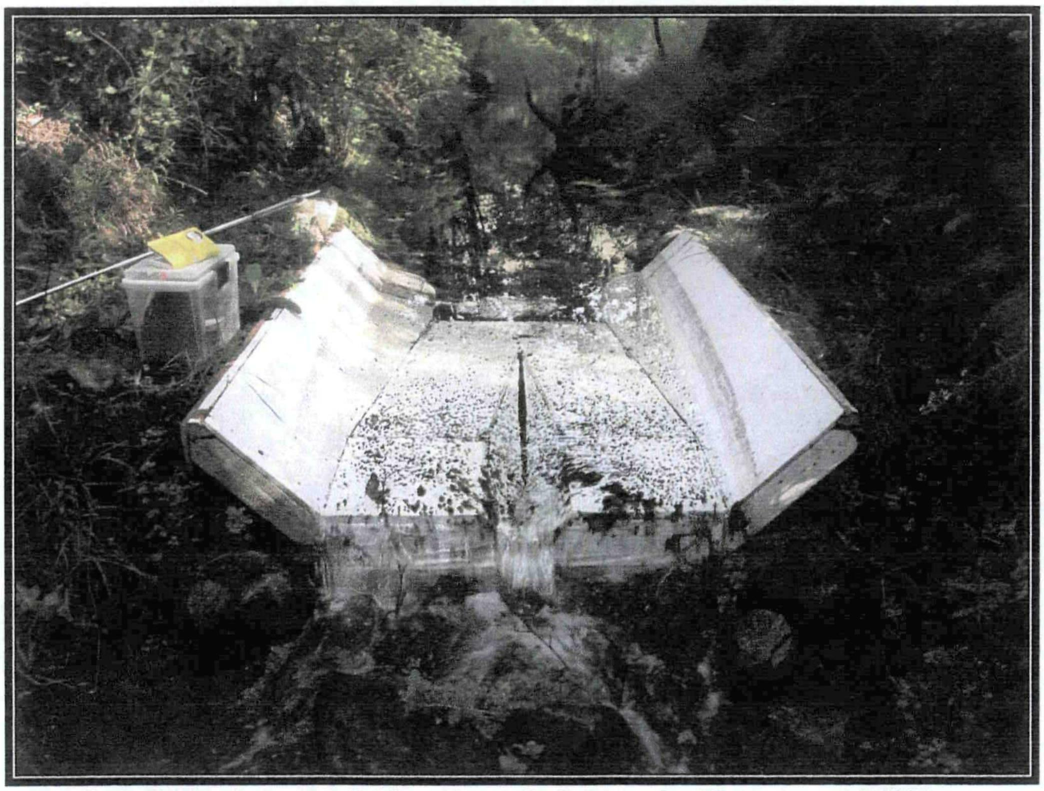
A.1.10. - H-Flume 7-8

A.1.11. - Weir 10,11,11

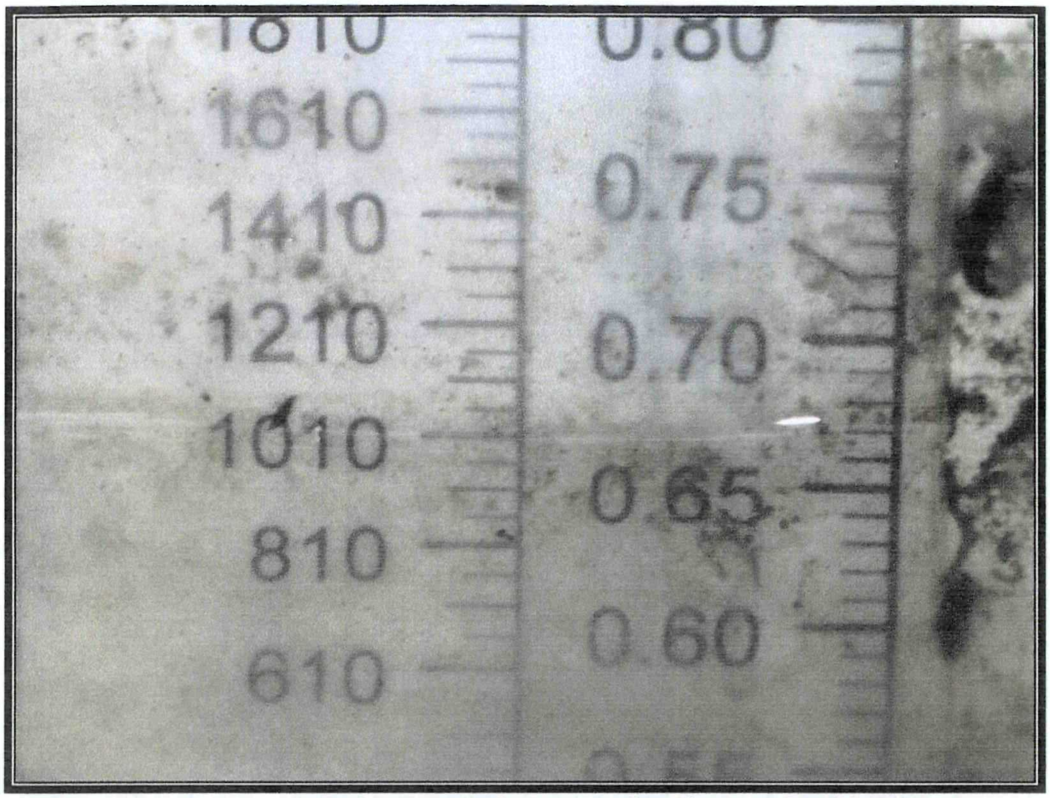
A.1.12. - V-Notch Weir Below Drain 11



A.1.13. 1 ft. H-Flume LRC01



A.1.14. - Lower Rainy Creek Repogle Flume – LRC01



A.1.15. - Lower Rainy Creek Repogle Flume Staff Gauge

A.1.16. - Carney Creek Parshall Flume – CC02

A.1.17. - Lower Rainy Creek Parshall Flume – LRC02

A.1.18. - Lower Rainy Creek Parshall Flume – LRC06

A.2 Drain Photographs from July 24, 2009 Inspection

A.2.1. – Outlet Drain 1

A.2.2. – Inside Drain 1

A.2.3. – Outlet Drain 2

A.2.4. – Inside Drain 2

A.2.5. – Outlet Drain 3

A.2.6. – Inside Drain 3

A.2.7. – Outlet Drain 4

A.2.8 – Inside Drain 4

A.2.9. – Outlet Drain 5

A.2.10. – Inside Drain 5

A.2.11. – Outlet Drain 6

A.2.12. – Inside Drain 6

A.2.13. - Drain 7 (upper right) and Drain 8 (center)

A.2.14. - Outlet Drain 7

A.2.15. – Inside Drain 7

A.2.16. – Outlet Drain 8

A.2.17. - Inside Drain 8

A.2.18. - Outlet Drain 9

A.2.19. - Inside Drain 9

A.2.20. - Outlet Drains 11 & 10

A.2.21. – Inside Drain 10

A.2.22. – Inside Drain 11

A.2.23. – Outlet Drain 12

A.2.24. – Inside Drain 12

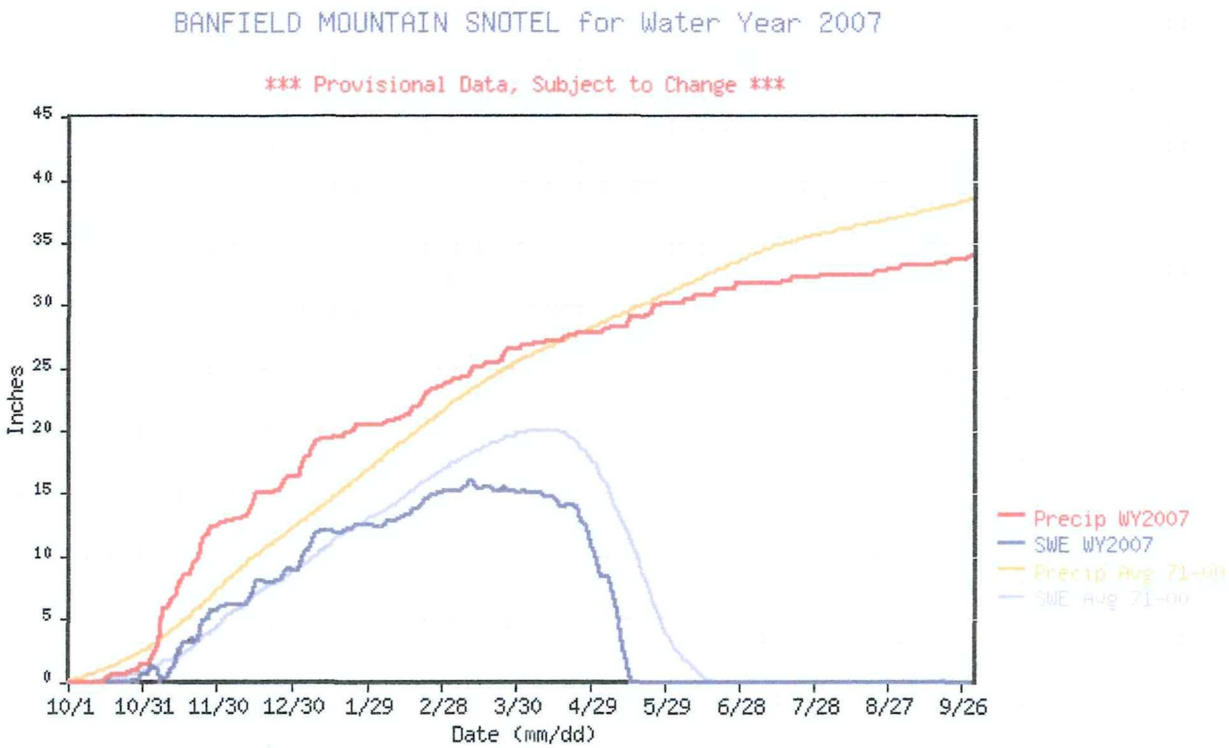
A.2.25. – Outside Drain 13

A.2.26. – Inside Drain 13

APPENDIX B

STREAM AND DRAIN FLOW DATA AND PLOTS

Water Year 2007 Graph for BANFIELD MOUNTAIN SNOTEL in Montana



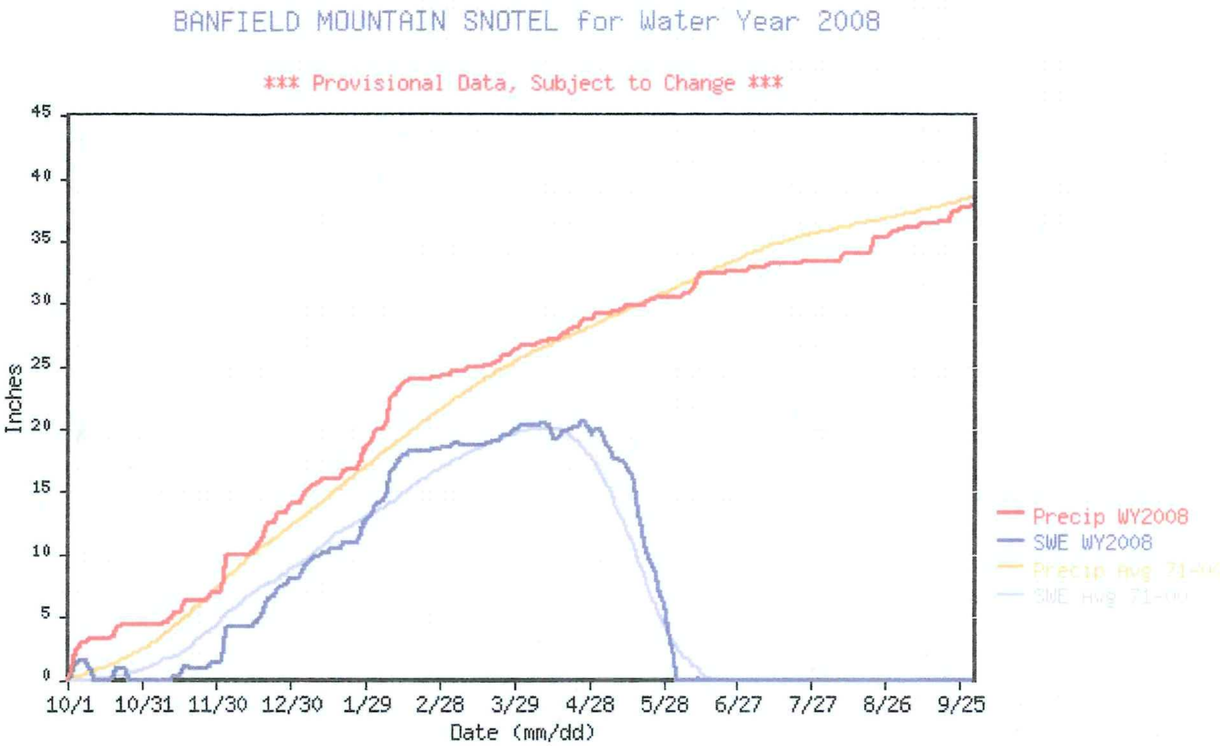
The following Water Years are also available for this site:
2008 Redraw Graph

Select Here to show this year, last year, and averages data for comparison.
Select Here to display all the available water year graphs for this site on one page.

United States Department of Agriculture
NRCS Natural Resources Conservation Service

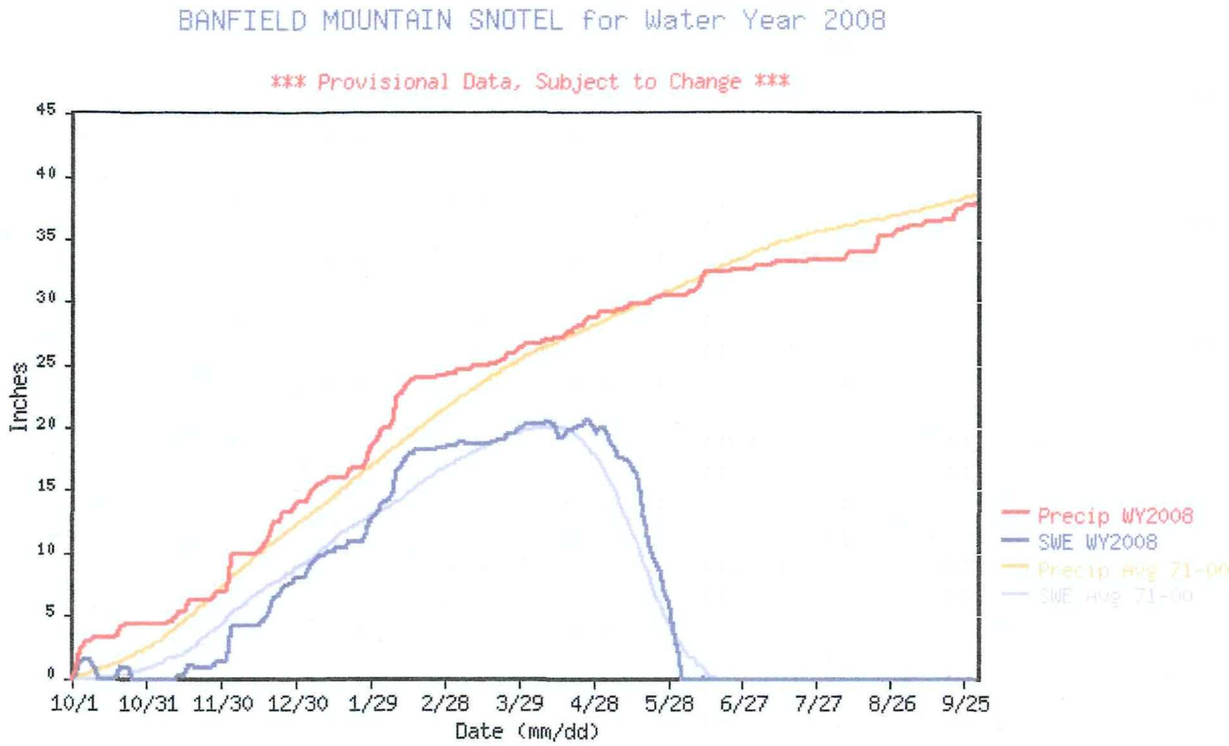
National Water and Climate Center

Water Year 2008 Graph for BANFIELD MOUNTAIN SNOTEL in Montana



The following Water Years are also available for this site:
2009 Redraw Graph

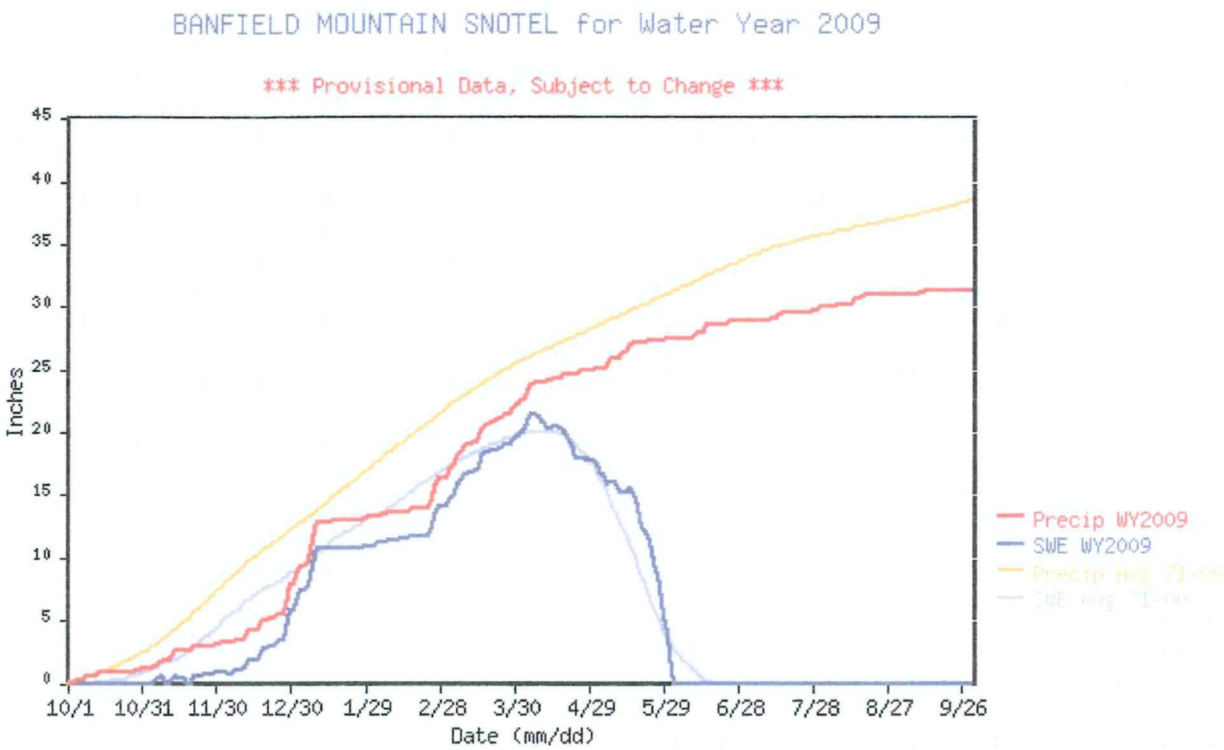
Select Here to show this year, last year, and averages data for comparison.
Select Here to display all the available water year graphs for this site on one page.


BANFIELD MOUNTAIN SNOTEL for Water Year 2008
*** Provisional Data, Subject to Change ***
Inches
Date (mm/dd)
10/1
10/31
11/30
12/30
1/29
2/28
3/29
4/28
5/28
6/27
7/27
8/26
9/25
0
5
10
15
20
25
30
35
40
45
Precip WY2008
SWE WY2008
Precip Avg 71-00
SWE Avg 71-00

United States Department of Agriculture
NRCS Natural Resources Conservation Service

National Water and Climate Center

Water Year 2009 Graph for BANFIELD MOUNTAIN SNOTEL in Montana



The following Water Years are also available for this site:
all. [Redraw Graph]

Select Here to show this year, last year, and averages data for comparison.
Select Here to display all the available water year graphs for this site on one page.

NORTH

KDID SURFACE WATER MONITORING
GARMIN GPS CSx
SCALE : AS SHOWN

REVISIONS DATE:	DESCRIPTION:	BY

DRAWN BY: TDL APPROVED BY: J J B

KOOTENAI DEVELOPMENT IMPOUNDMENT DAM
FOR
REMEDIAN GROUP
SECTION 6, T. 28N., R. 21W., P.M., M., FLATHEAD COUNTY

BILLMAYER ENGINEERING
2191 THIRD AVE. E. KALISPELL, MT. 59901
PHONE: (406) 257-8708
FAX: (406) 257-8710
EMAIL: info@billmayer.com
ONLINE: http://www.billmayer.com

DRAWING TITLE:
SURFACE WATER MONITORING

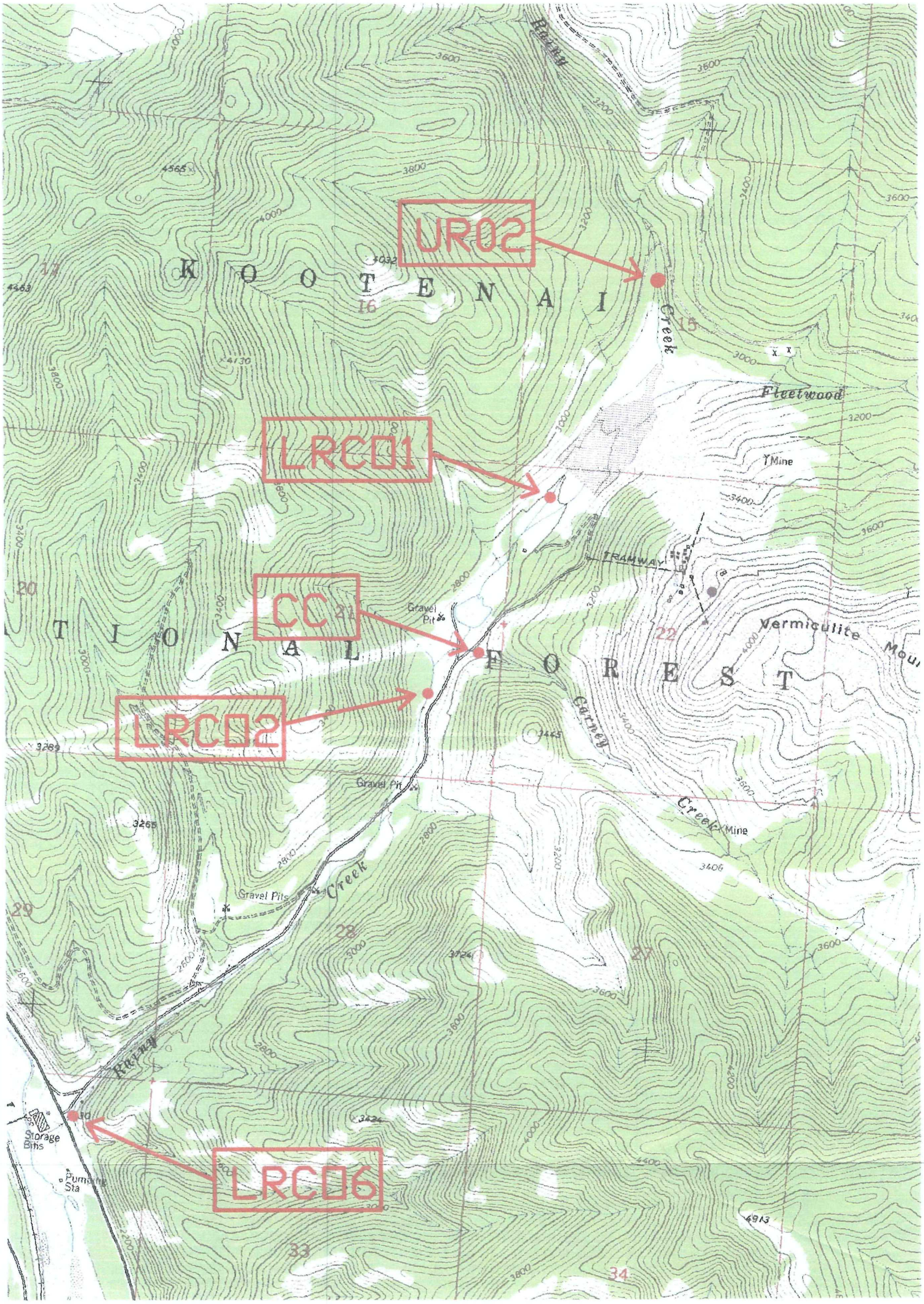
SCALE: AS SHOWN

DATE:	PROJECT NO:
February 18, 2010	R.56.1

DRAWING NUMBER:
1 of 1

R.28.1\dwg\piezometer locations.dwg

S:\Land Projects R2\R.56.1\dwg\piezometer locations.dwg 2/18/2010 4:36:22 PM MST



NORTH

STREAM GAGE LOCATIONS

SCALE : 1" = 500'

DRAWING NUMBER: 1 of 1	DATE: SEPT. 23, 2009	PROJECT NO: R.56.1	SCALE: AS SHOWN	DRAWING TITLE: STREAM GAGE LOCATIONS

BILLMAYER & HAFFERMAN, INC.

STREAM GAGE LOCATIONS

FOR

REMEDIUM GROUP

T. 31N., R. 30W., P.M., M., LINCOLN COUNTY

DRAWN BY: TDL APPROVED BY: JJB

REVISIONS DATE:	DESCRIPTION:	BY

R.56.1\dwg\StreamGage locations.dwg

NORTH

KDID DRAIN LOCATIONS
GARMIN GPS CSx
SCALE : AS SHOWN

REVISIONS		
DATE:	DESCRIPTION:	BY

DRAWN BY: TDL APPROVED BY: J J B

KOOTENAI DEVELOPMENT IMPOUNDMENT DAM

FOR

REMEDIAN GROUP

SECTION 6, T. 28N., R. 21W., P.M., M., FLATHEAD COUNTY

BILLMAYER ENGINEERING
2191 THIRD AVE. E. KALISPELL, MT. 59901
PHONE: (406) 257-8708
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EMAIL: info@billmayer.com
ONLINE: http://www.billmayer.com

DRAWING TITLE:

DRAIN LOCATIONS

SCALE:
AS SHOWN

DATE:
February 18, 2010

PROJECT NO:
R.56.1

DRAWING NUMBER:
1 of 1

R.26.1\dwg\piezometer locations.dwg

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Kootenai Impoundment Dam **Stream & Drain Flow Measurements**
R.56.1

Gage Heights

OT= Over Topping

Date	W1234 (GH, ft)	W5 (GH, ft)	W6 (GH below top, ft.)	W78 (GH, ft.)	W10,11, 12 (GH, ft.)	W12 (GH, ft)	UR02 (GH, ft.)	LRC6 (GH, ft)	LRC01 (GH, ft)	LRC2 (GH, ft)	CC (GH, ft.)	Reservoir (GH)
9/25/07	0.036	0.089				0.161			0.75			
9/26/07	0.042	0.083				0.146						
11/9/07	0.0417	0.063	0.938			0.146						
12/26/08	0.0417	0.083	0.969			0.146						
2/7/08	0.0417	0.094	0.969			0.146						
3/10/08	0.0417	0.042	0.901			0.177						
4/23/08	0.1094	0.115	0.844			0.161						
5/16/08	**OT**	0.104	0.615			0.344						
5/20/08	**OT**		0.667			0.438						
6/3/08	**OT**	0.208	0.698			0.427			1.24			
7/3/08	0.1771	0.125	0.771			0.385						
8/8/08	0.08	0.104	0.823			0.260						
10/2/08	0.02	0.083	0.792			0.208			0.55			
12/1/08	0.02	0.073	0.800			0.229						
12/12/08										0.35	0.2	
1/15/09	0.02	0.082				0.198	0.29			0.32	0.1	
2/20/09	0.02	0.042	0.938			0.219	0.19		0.42	0.46	0.15	1.32
4/7/09								0.74		0.68	0.43	
4/13/09	0.13	0.083	0.813			0.344		0.85		0.65	0.43	
4/24/09	0.36		0.771			0.406		1.33		1.41		2.15
4/30/09	**OT**	0.208	0.750			0.417	1.14	1.265		1.302	0.55	1.9
5/1/09	0.83	0.188	0.760		0.55	0.427	1.11	1.21				1.95
5/5/09	0.80	0.167	0.745	0.168	0.522	0.417		1.25		1.28	0.475	2.05
5/7/09								1.37		1.38	0.52	
5/19/09	0.85			0.18	0.57		1.47			1.36	0.463	2.17
5/27/09	0.85	0.188		0.18	0.57	0.458	1.305		0.97			2.11
6/26/09	0.478	0.146	0.854	0.125	0.51	0.396	0.61	0.77	0.79	0.769	0.18	1.29
6/29/09							0.565					1.18
7/24/09	0.250	0.104		0.11	0.46	0.292	0.375	0.52	0.75	0.51	0.135	0.4
8/21/09	0.12		0.917	0.04	0.44		0.32	0.425	0.68	0.378	0.131	0.04
9/11/09	0.115	0.104	0.979	0.120	0.300	0.188	0.190	0.38	0.640	0.315	0.14	-0.30208

V-Notch Weir Calculations:

V-Notch Angle (Standard): 90 θ, Degrees

$Q = 4.28 * C * \tan(\theta/2) * (h+k)^{5/2}$

$C = 0.607165052 - 0.00074466963 + 6.10393334\times10^{-6} *\theta^2$

$k = 0.0144902648 - 0.00033955535 + 3.29819003\times10^{-6} *\theta^2 - 1.06215442\times10^{-8} *\theta^3$

Q1234 ft. rec.= 3.33(L-0.2GH)H^3/2

C = Discharge Coefficient

h = head (ft)

k = head correction factor (ft)

H-Flume Calculations:

$\log Q = A + B \log h_a + C^*[\log (h_a)]^2$

$Q = m^3/s$

h_a = meters (m)

Flume Depth (ft) (D)	A	B	C
0.5	0.0372	2.6629	0.1954
0.75	0.0351	2.6434	0.2243
1.0	0.0206	2.5902	0.2281
2.0	0.0237	2.4918	0.2605

F02 = 0.75 ft H-flume
W1234 = V-notch replaced with 1ft H-flume
W78 = 0.5 ft H-flume
W10,11,12 = 1.0 ft H-flume
LRC01 = 2.0 ft H-flume
UR02 = 2.0 ft H-flume

Parshal Calculations:

1 ft.: $Q = 1795\ H^{1.522}$

0.75 ft: $Q = 1378\ H^{1.53}$

LRC06 = 1 ft Parshall
LRC02 = 1 ft Parshall
CC01= 0.75 ft Parshall

Kootenai Impoundment Dam KDID 2008 - 2009 Water Year Hydrography Data Revised 1/10/2009
R.56.1 BHI Surface Water; Stream & Drain Flow Data
Hafferman R.56.1/documents/Drain and Stream Flow Excel Files

Monthly Flow Rates (All flow rates are in gallons perminute (Q=gpm))

Type	H-Flume	Extrapolated		V -> H	V	Free Outfall	H-Flume	H-Flume
Date	Upper Rainy Creek	Fleetwood Creek	Upper Rainy Creek-Fleetwood Creek Combined	W1234 (Qgpm)	W5 (Qgpm)	D6 (Qgpm)	W 7, 8 (Qgpm)	W10,11,12 (Qgpm)
10/2/2008	84	57	141	5	2	451	15	63
12/1/2008	67	45	112	5	2	427	15	59
12/12/2008	54	37	91	5	2	100	14	45
1/15/2009	77	52	129	5	2	120	12	34
2/20/2009	35	24	59	5	0	118	11	75
4/7/2009	950	646	1596	37	2	240	12	92
4/13/2009	1072	729	1801	64	2	392	12	125
4/24/2009	1261	857	2118	305	5	514	17	139
4/30/2009	1451	987	2438	550	23	580	15	211
5/1/2009	1184	805	1989	570	18	547	15	223
5/5/2009	1540	1047	2587	523	13	598	13	199
5/7/2009	1668	1134	2802	535	14	803	14	205
5/19/2009	2435	1656	4092	602	16	837	16	242
5/27/2009	1853	1260	3113	602	18	750	16	242
6/26/2009	348	237	585	163	9	514	7	189
6/29/2009	297	202	498	150	9	752	6	185
7/24/2009	128	87	215	41	4	365	5	150
8/21/2009	94	64	157	20	4	313	6	136
9/11/2009	35	24	58	13	4	161	7	60
10/23/2009	25	17	43	9	2	135	6	62
Volume URC AF	**687**	**467**	**1155**	**167**	**8**	**580**	**19**	**178**
Volume URC Ga	**223,982,999**	**152,308,439**	**376,291,439**	**54,544,585.52**	**2,588,183.80**	**189,126,791.06**	**6,074,849.55**	**58,106,047.93**
			Net difference	**-23**	**(7,466,147)**	**(Groundwater/Evaporation Loss)**		
Total Flow Spillway and Drains (AF.)			**1132**					
Total Flow Spillway and Drains (gal.)			**368,825,292**					
			Net Difference	**388**	**126,304,056.92**	**(Net Groundwater/Surface Water Gain)**		
Volume Raincy Creek at LRC06 (AF)			**1519**					
Volume Raincy Creek at LRC06 (gal)			**495,129,348.50**					

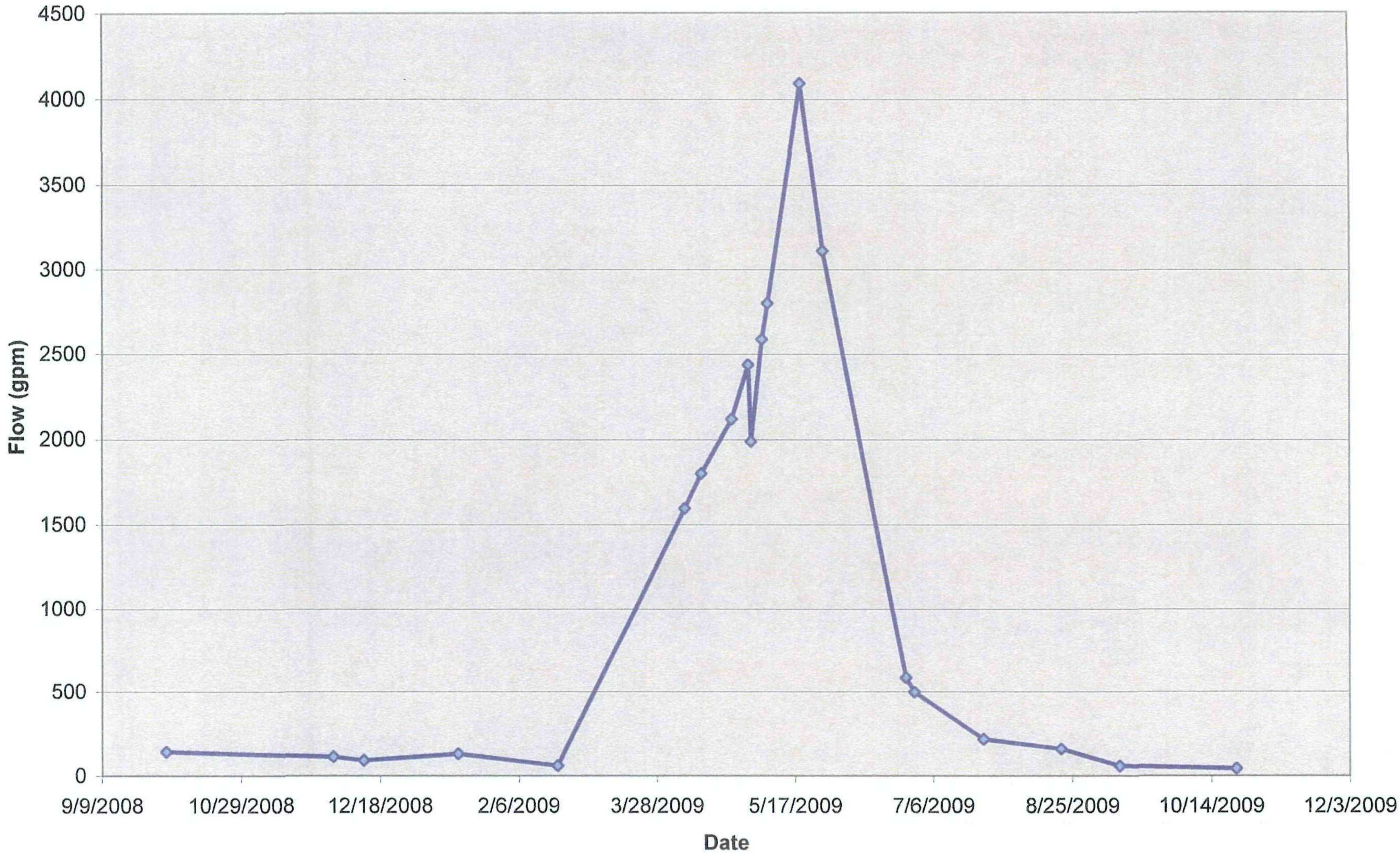
Kootenai Impoundment Dam		KDID 2008 - 2009 Water Year Hydrography Data			Revised		1/10/2009	
R.56.1	BHI	Surface Water; Stream & Drain Flow Data						
		Hafferman		R.56.1/documents/Drain and Stream Flow Excel Files				
Monthly Flow Rates (All flow rates are in gallons perminute (Q=gpm))								
Type	H-Flume	Extrapolated		V -> H	V	Free Outfall	H-Flume	H-Flume
Date	Upper Rainy Creek	Fleetwood Creek	Upper Rainy Creek-Fleetwood Creek Combined	W1234 (Qgpm)	W5 (Qgpm)	D6 (Qgpm)	W 7, 8 (Qgpm)	W10,11,12 (Qgpm)
MONTHLY VOLUME CALCULATIONS BY AVERAGE END METHOD								
10/2/2008								
12/1/2008	19.95	13.57	33.52	1.27	0.55	116.16	4.01	16.11
12/12/2008	2.93	1.99	4.93	0.23	0.09	12.78	0.71	2.52
1/15/2009	9.83	6.68	16.51	0.72	0.32	16.49	1.94	5.95
2/20/2009	8.89	6.05	14.94	0.76	0.22	18.89	1.83	8.67
4/7/2009	99.90	67.93	167.84	4.21	0.20	36.31	2.32	16.94
4/13/2009	26.75	18.19	44.94	1.34	0.05	8.36	0.31	2.87
4/24/2009	56.58	38.48	95.06	8.96	0.18	21.97	0.71	6.40
4/30/2009	35.88	24.40	60.28	11.31	0.37	14.47	0.42	4.63
5/1/2009	5.81	3.95	9.76	2.47	0.09	2.48	0.07	0.96
5/5/2009	24.03	16.34	40.36	9.64	0.27	10.10	0.25	3.72
5/7/2009	14.15	9.62	23.77	4.67	0.12	6.18	0.12	1.78
5/19/2009	108.57	73.83	182.40	30.08	0.78	43.39	0.79	11.82
5/27/2009	75.64	51.44	127.08	21.25	0.59	27.99	0.55	8.53
6/26/2009	145.61	99.01	244.62	50.65	1.79	83.61	1.50	28.48
6/29/2009	4.27	2.90	7.17	2.08	0.12	8.37	0.09	2.47
7/24/2009	23.41	15.92	39.33	10.53	0.72	61.57	0.64	18.45
8/21/2009	13.69	9.31	23.00	3.75	0.49	41.86	0.68	17.68
9/11/2009	5.94	4.04	9.97	1.51	0.37	21.95	0.56	9.07
10/23/2009	5.55	3.77	9.33	1.95	0.61	27.45	1.15	11.25
VOLUMES	**687**	**467**	**1155**	**167**	**8**	**580**	**19**	**178**

Monthly Flow Rates (All flow rates are in gallons perminute (Q=gpm))

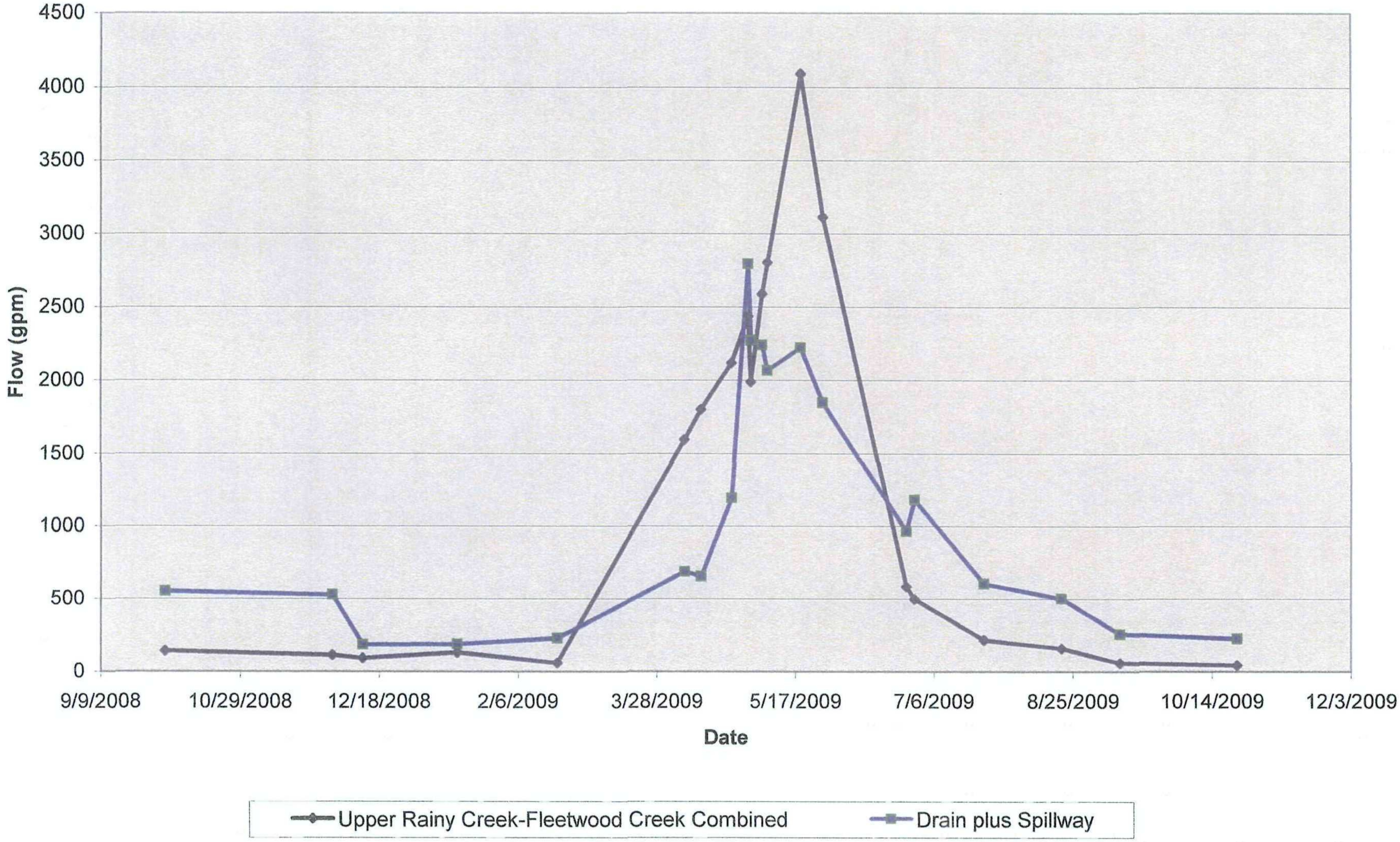
V-Notch Weir	Extrapolated		Staff Gauge		1 ft. Parshall	0.75 ft.Parshall		1 ft. Parshall	
W12 (Qgpm)	D9	**Total Drain Flow at Toe**	**SPILLWAY**	**Drain plus Spillway**	LRC02 (Qgpm)	CC01 (Qgpm)	**LRC02-CC01**	LRC6 (Qgpm)	Date
23	17	554	0	554	745	245	500	409	10/2/2008
29	22	529	0	529	434	220	214	315	12/1/2008
24	18	184	0	184	363	117	246	321	12/12/2008
20	15	188	0	188	317	41	276	540	1/15/2009
26	19	229	0	229	551	76	475	604	2/20/2009
72	54	436	250	686	998	380	618	1135	4/7/2009
79	59	655	0	655	932	380	552	1402	4/13/2009
119	89	1069	125	1194	3028	471	2557	2771	4/24/2009
127	95	1474	1320	2794	2682	552	2130	2567	4/30/2009
135	101	1473	800	2273	2669	530	2139	2399	5/1/2009
127	95	1441	800	2241	2614	441	2172	2521	5/5/2009
130	97	1667	400	2067	2931	507	2424	2898	5/7/2009
148	111	1824	400	2224	2866	232	2634	2785	5/19/2009
160	120	1747	100	1847	2507	187	2320	2488	5/27/2009
111	84	966	0	966	1204	100	1104	1206	6/26/2009
105	79	1181	0	1181	1146	96	1050	1148	6/29/2009
52	39	605	0	605	661	64	596	663	7/24/2009
32	24	503	0	503	408	61	347	488	8/21/2009
18	13	257	0	257	309	68	241	412	9/11/2009
13	10	224	0	224	273	68	205	420	10/23/2009
90	**68**	**1020**	**111**	**1132**	**1494**	**279**	**1215**	**1519**	
29,407,278.65	**22,055,458.99**	**332,495,917**	**36,329,375**	**368,825,292**	**486,830,420**	**90,828,163**	**396,002,257**	**495,129,348**	

Monthly Flow Rates (All flow rates are in gallons perminute (Q=gpm))									
V-Notch Weir	Extrapolated		Staff Gauge		1 ft. Parshall	0.75 ft.Parshall		1 ft. Parshall	
W12 (Qgpm)	D9	**Total Drain Flow at Toe**	**SPILLWAY**	**Drain plus Spillway**	LRC02 (Qgpm)	CC01 (Qgpm)	**LRC02-CC01**	LRC6 (Qgpm)	Date
MONTHLY VOLUME CALCULATIONS BY AVERAGE END METHOD									Date
									10/2/2008
6.82	5.12	143.23	0.00	143.23	155.97	61.52	94.46	95.81	12/1/2008
1.28	0.96	17.30	0.00	17.30	19.34	8.18	11.15	15.43	12/12/2008
3.30	2.47	27.91	0.00	27.91	50.98	11.85	39.13	64.55	1/15/2009
3.63	2.72	33.09	0.00	33.09	68.85	9.23	59.62	90.81	2/20/2009
9.94	7.45	67.44	25.36	92.80	157.06	46.21	110.85	176.39	4/7/2009
2.00	1.50	14.43	3.31	17.74	25.53	10.05	15.48	33.56	4/13/2009
4.79	3.59	41.81	3.03	44.84	96.04	20.64	75.40	101.19	4/24/2009
3.25	2.44	33.65	19.12	52.76	75.55	13.53	62.01	70.61	4/30/2009
0.58	0.43	6.50	4.67	11.17	11.80	2.39	9.41	10.95	5/1/2009
2.30	1.73	25.71	14.11	39.82	46.59	8.56	38.02	43.39	5/5/2009
1.13	0.85	13.71	5.29	19.00	24.45	4.18	20.27	23.90	5/7/2009
7.35	5.51	92.37	21.17	113.54	153.38	19.54	133.83	150.38	5/19/2009
5.44	4.08	62.99	8.82	71.81	94.78	7.39	87.39	93.01	5/27/2009
17.98	13.49	179.51	6.61	186.12	245.46	18.97	226.49	244.34	6/26/2009
1.43	1.07	14.20	0.00	14.20	15.54	1.30	14.25	15.57	6/29/2009
8.68	6.51	98.42	0.00	98.42	99.57	8.83	90.74	99.85	7/24/2009
5.21	3.91	68.38	0.00	68.38	65.99	7.76	58.24	71.09	8/21/2009
2.30	1.72	35.19	0.00	35.19	33.23	6.00	27.23	41.66	9/11/2009
2.85	2.14	44.56	0.00	44.56	53.91	12.60	41.31	77.00	10/23/2009
90	**68**	**1020**	**111**	**1132**	**1494**	**279**	**1215**	**1519**	

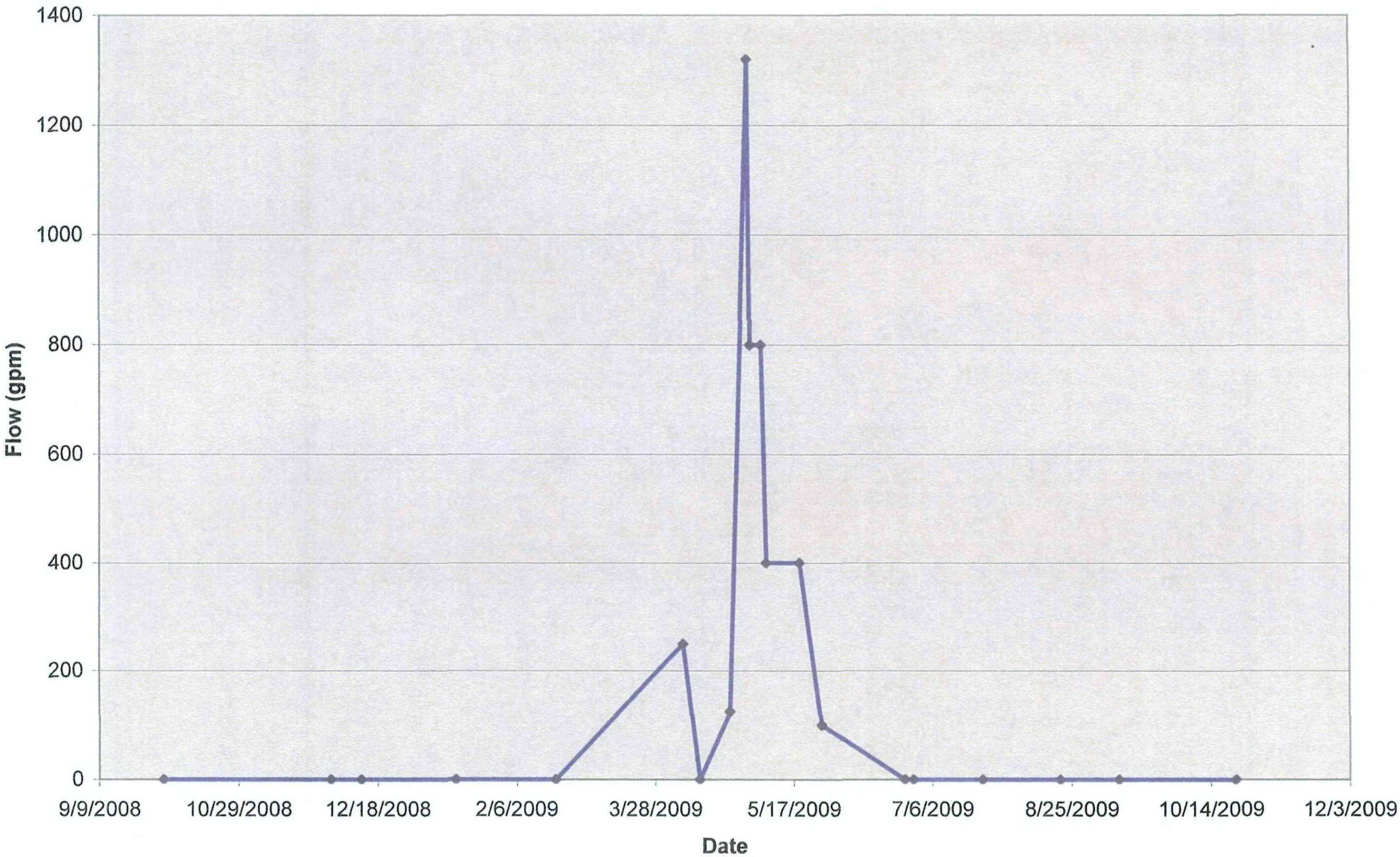
Upper Rainy Creek and Fleetwood Creek 2008-2009 Inflow Hydrograph



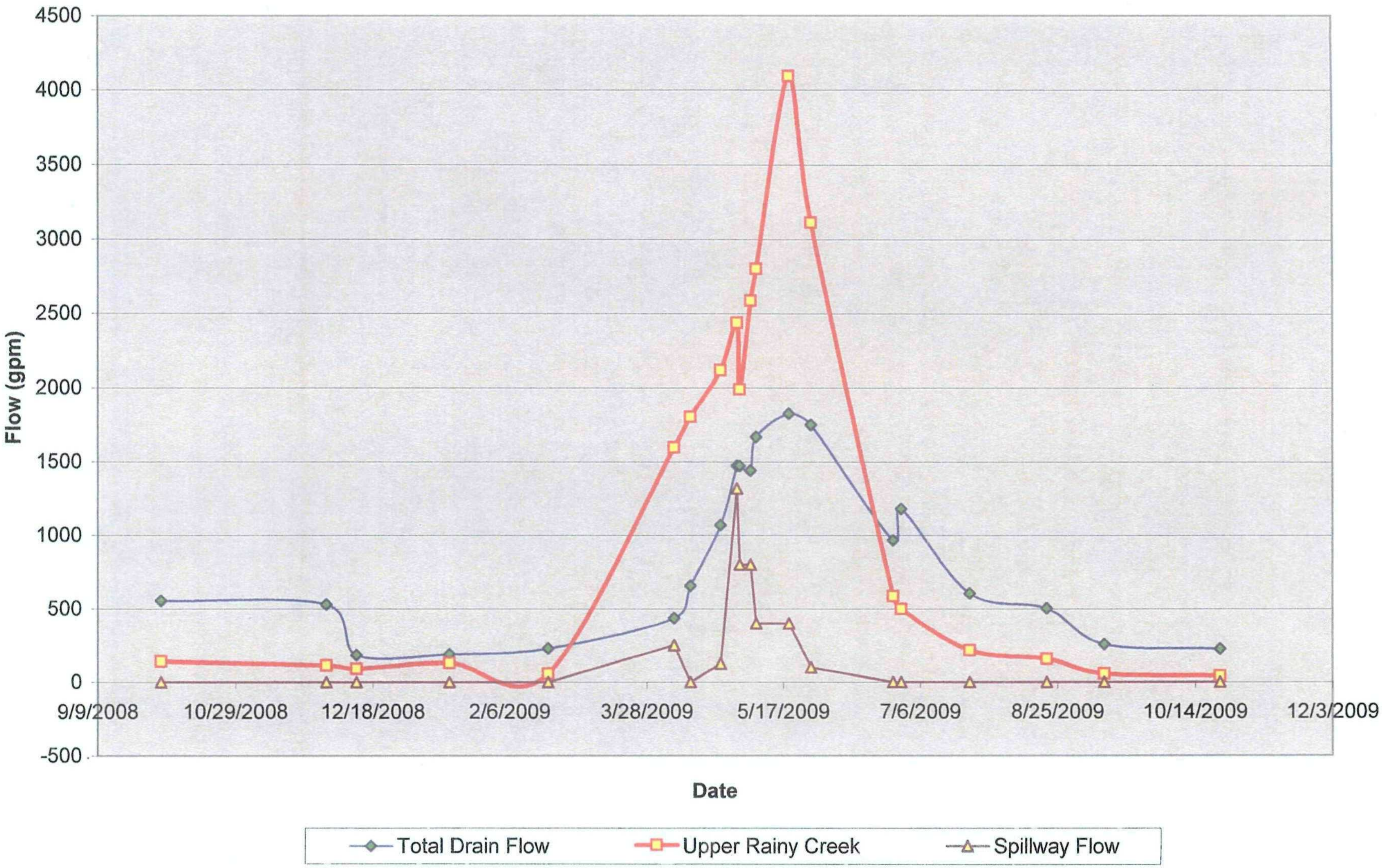
Upper Rainy Creek at URC02 and Lower Rainy Creek at LRC01 Plus Spillway Flows
2008 - 2009 Water Year



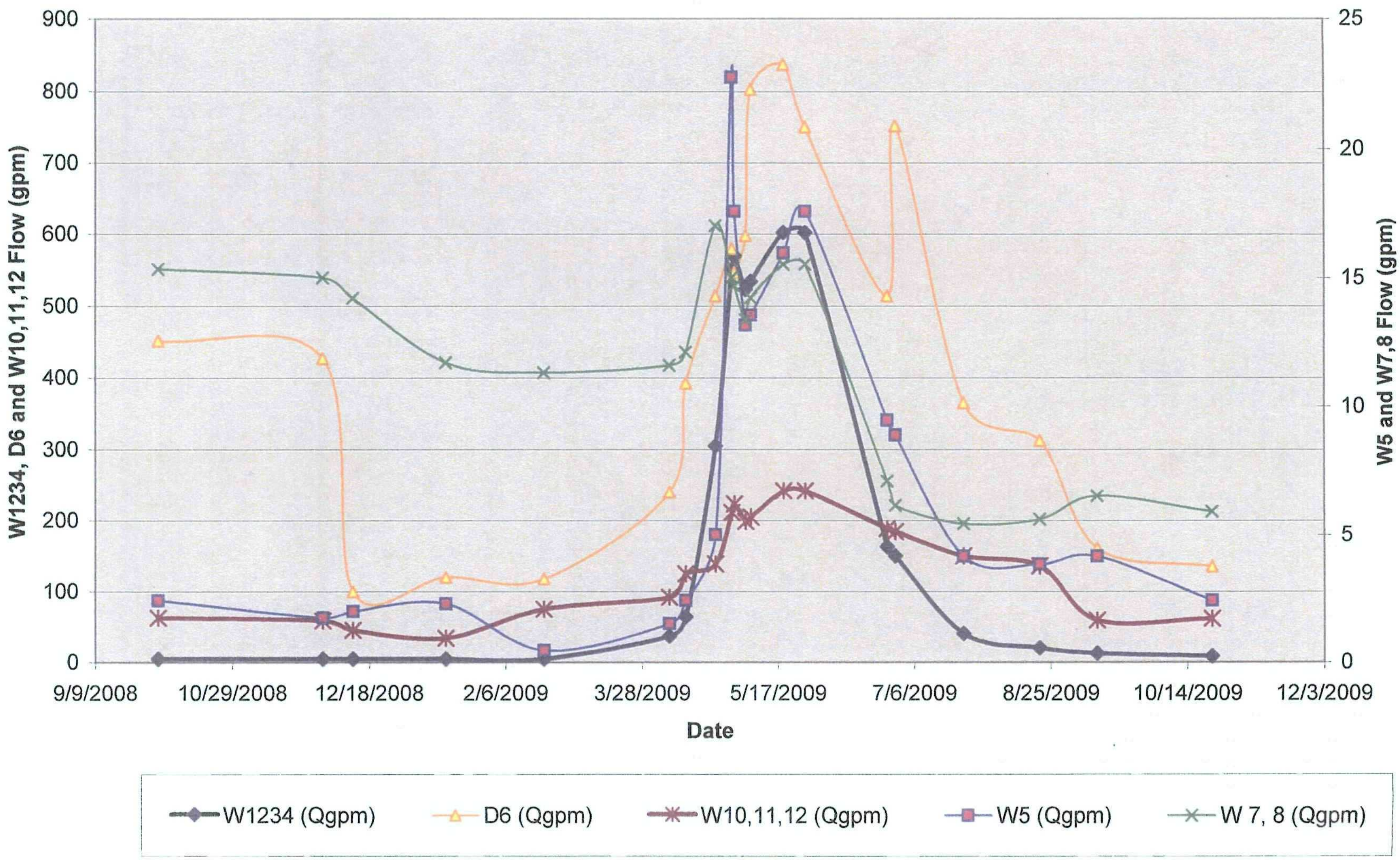
KDID Spillway Flow 2009



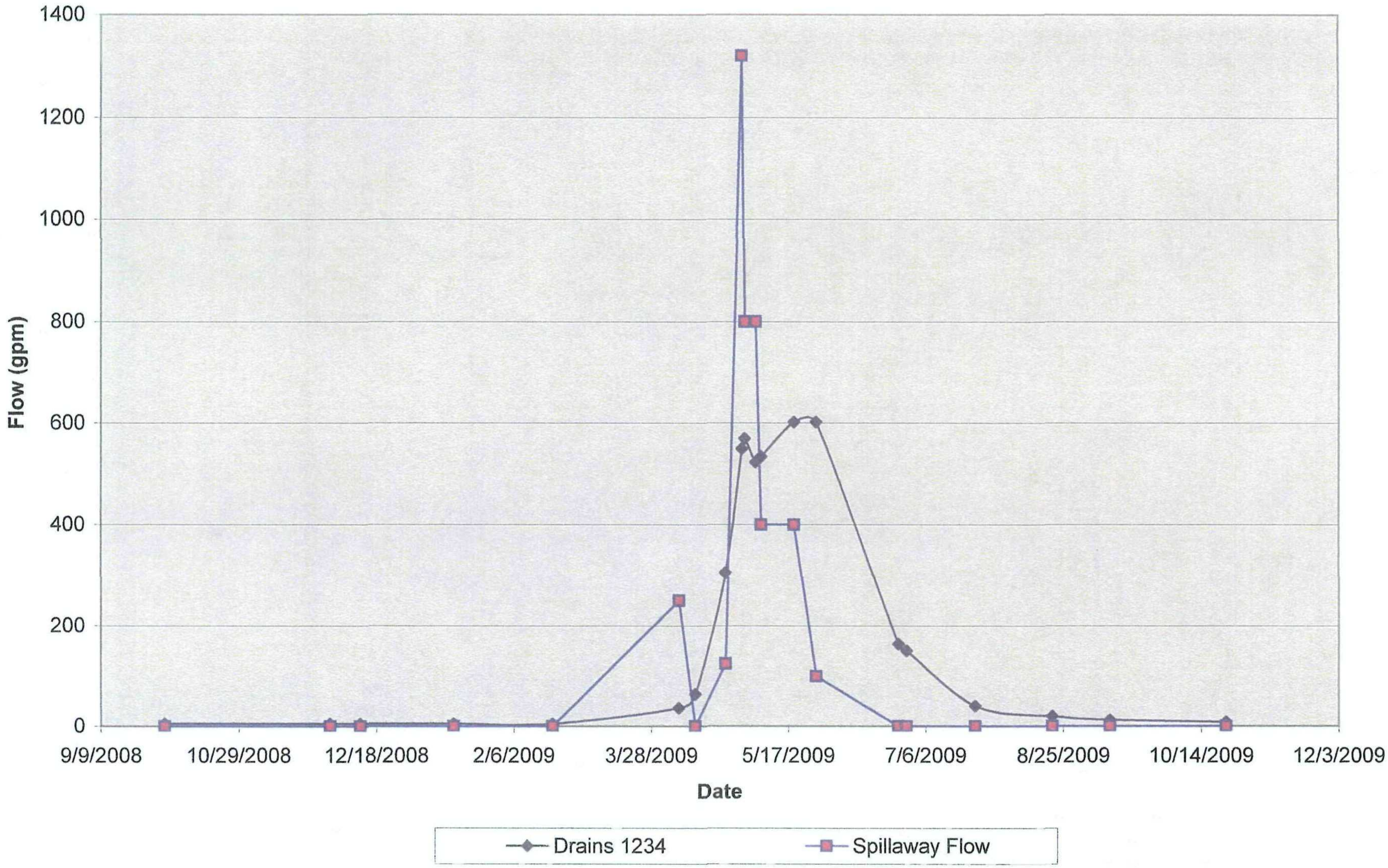
Upper Rainy Creek Versus Total Drain Flow and Total Spillway Flow



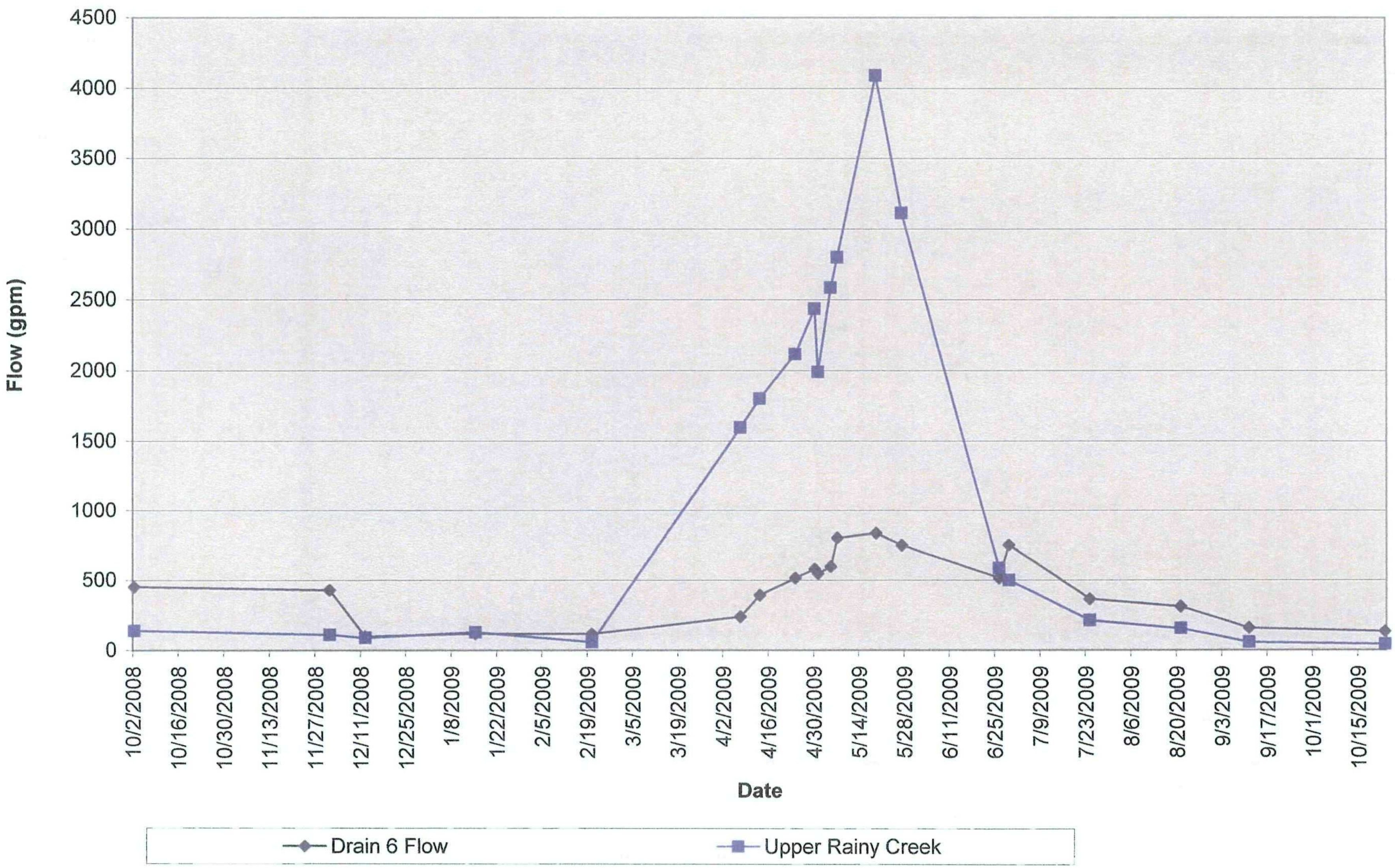
All KDID Toe Drains



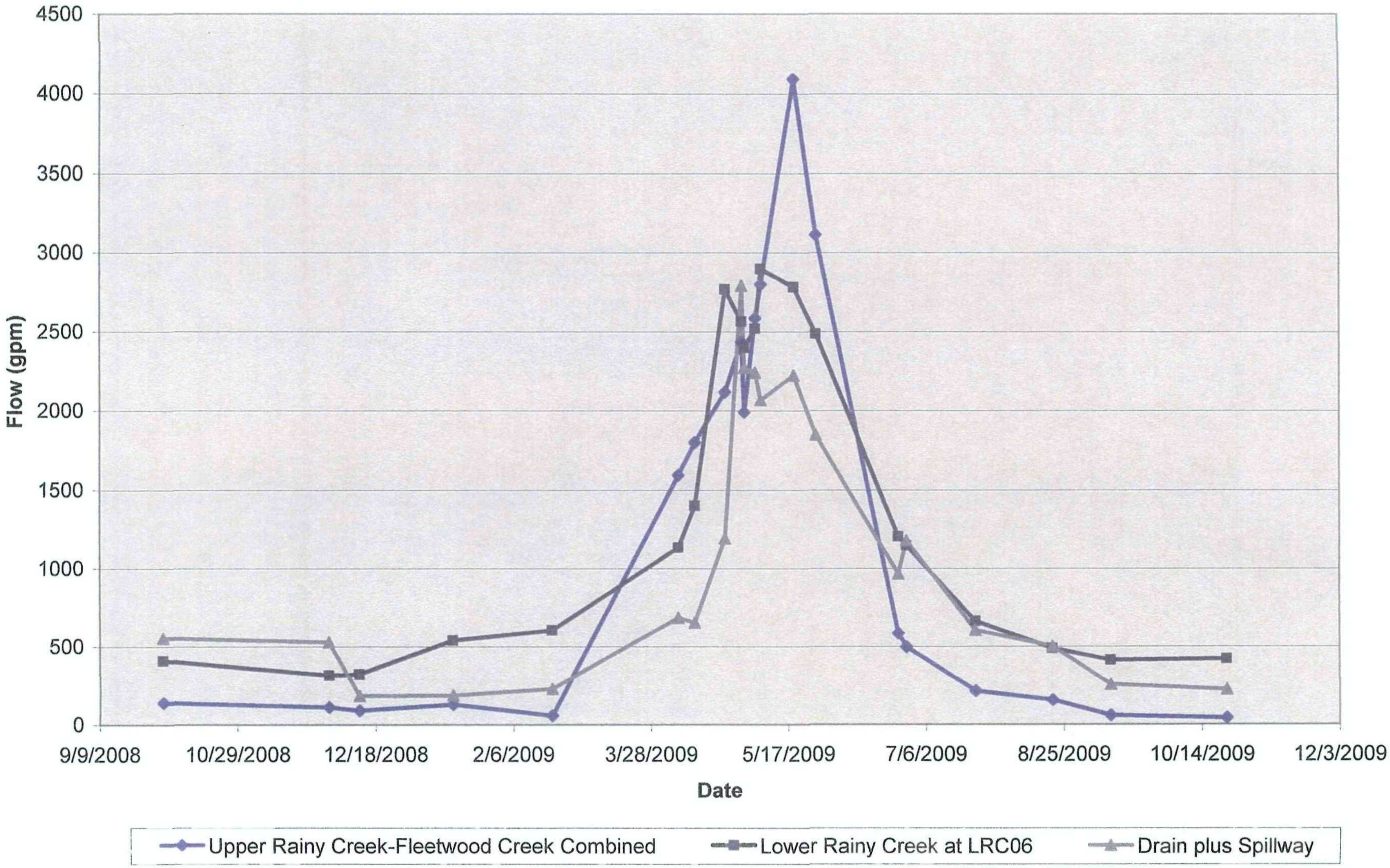
Drains 1,2,3 &4 versus Spillway Flow



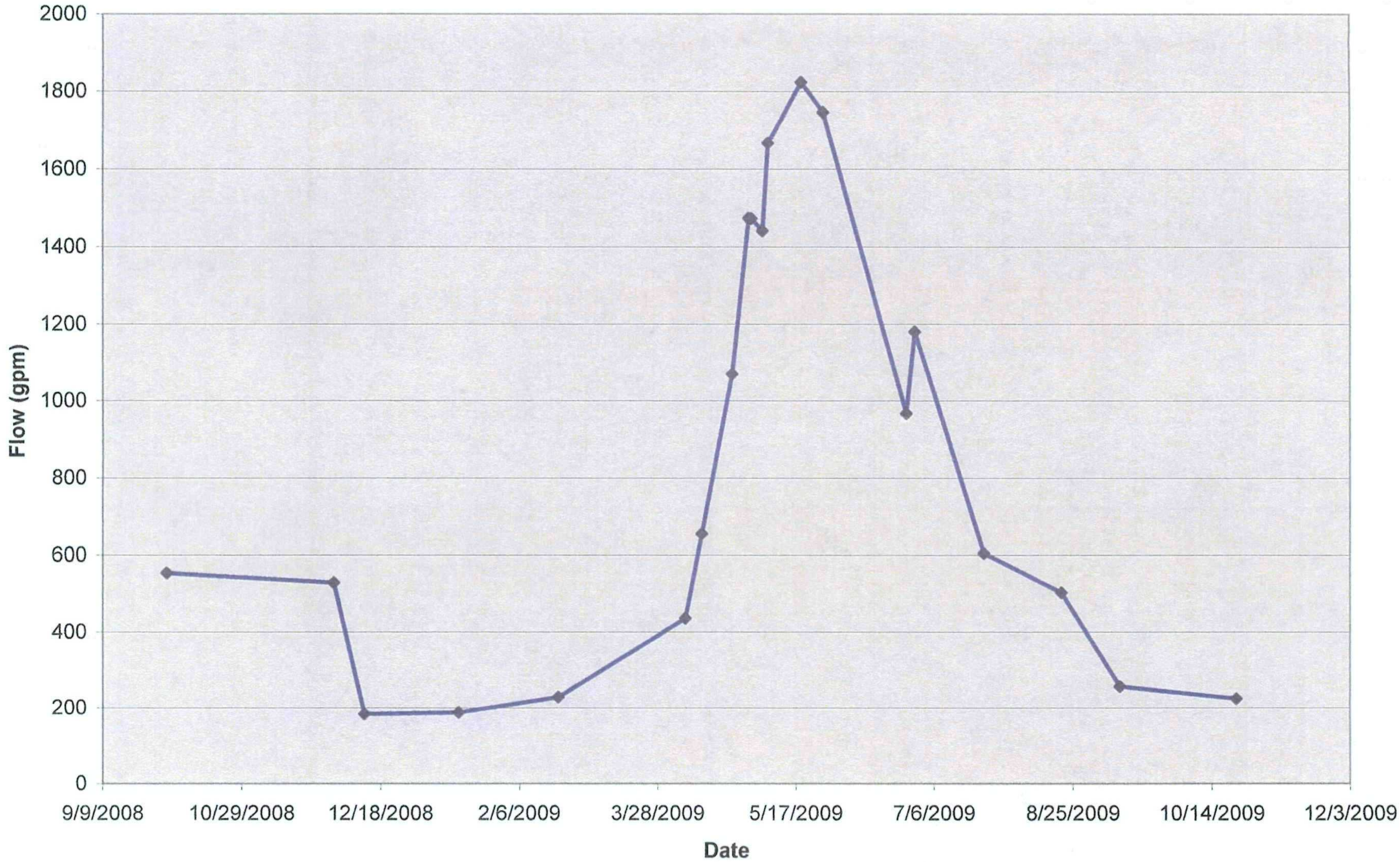
Upper Rainy Creek Inflow Compared to Total Flow Drain 6



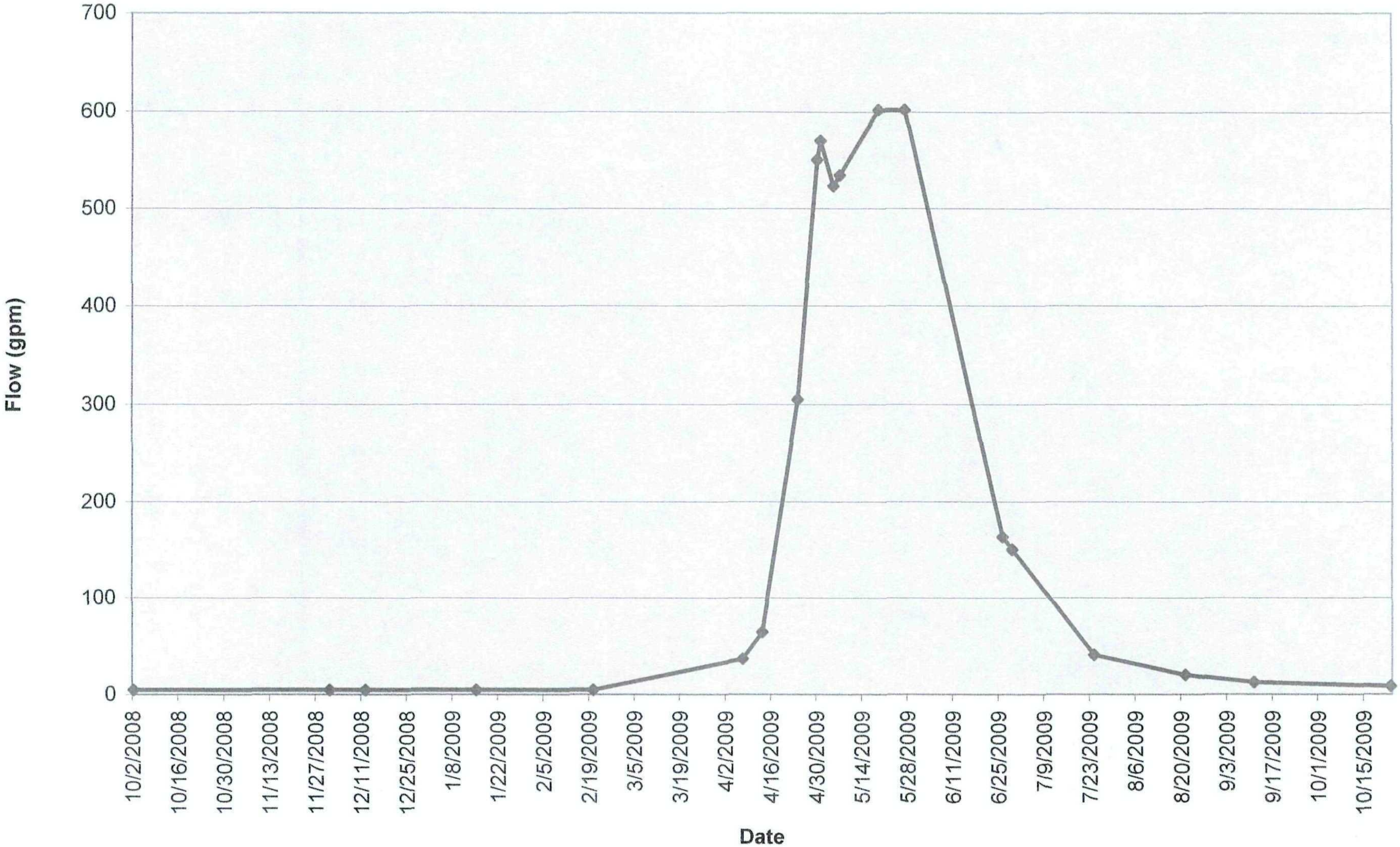
Upper and Lower Rainy Creek 2008-2009 Water Year



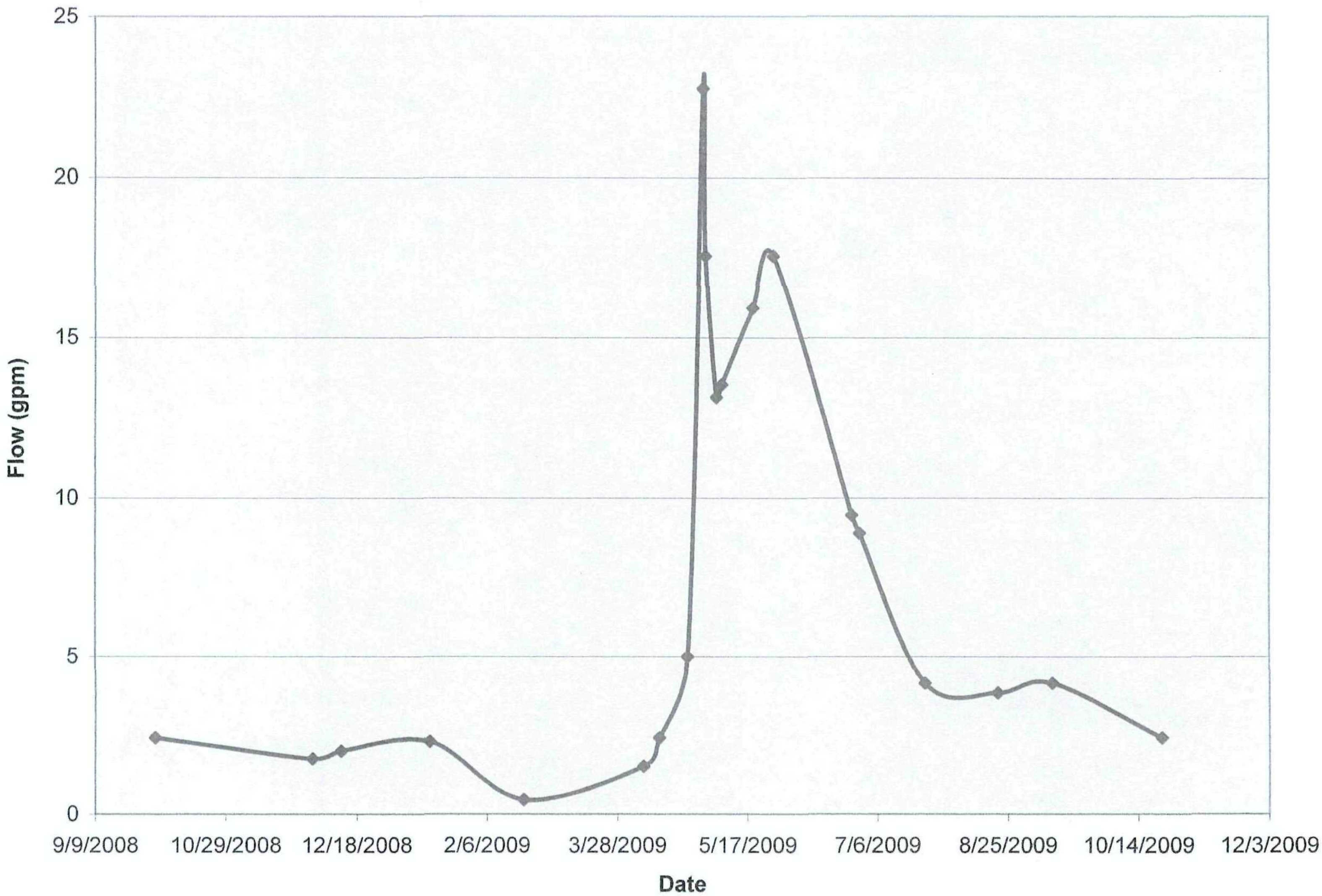
KDID Total Drain Flow 2008-2009



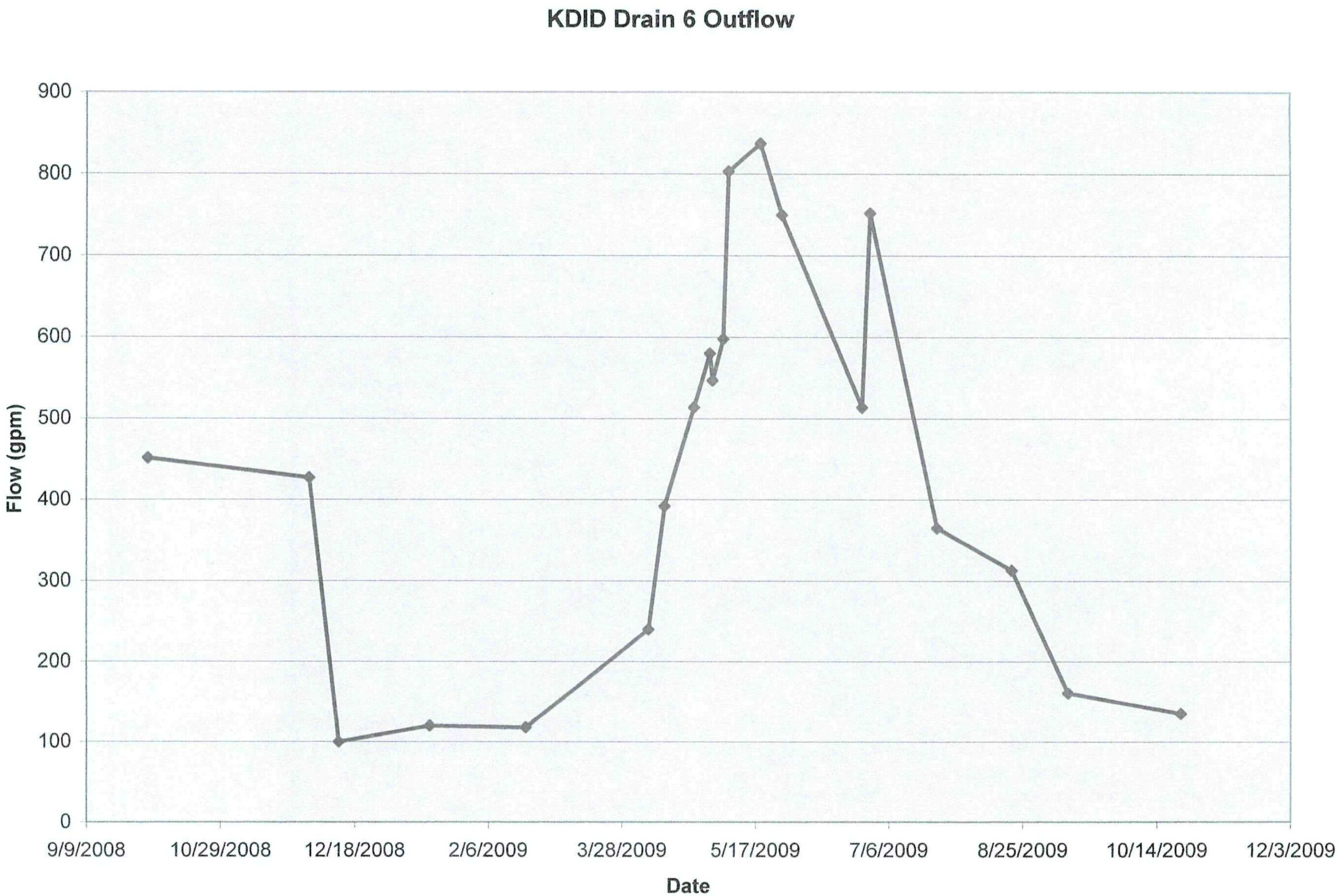
KDID Flume 1-2-3-4

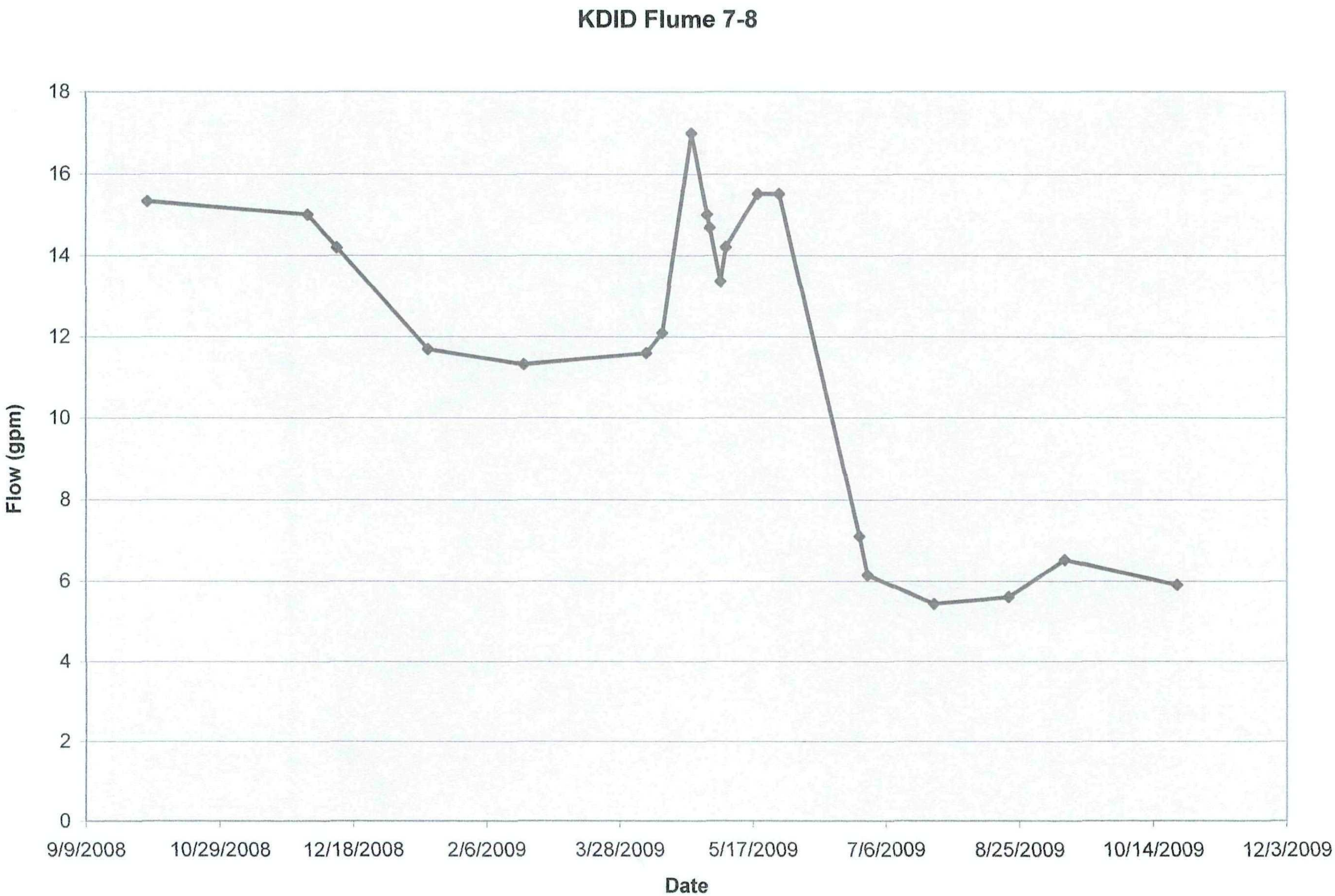


KDID Weir 5

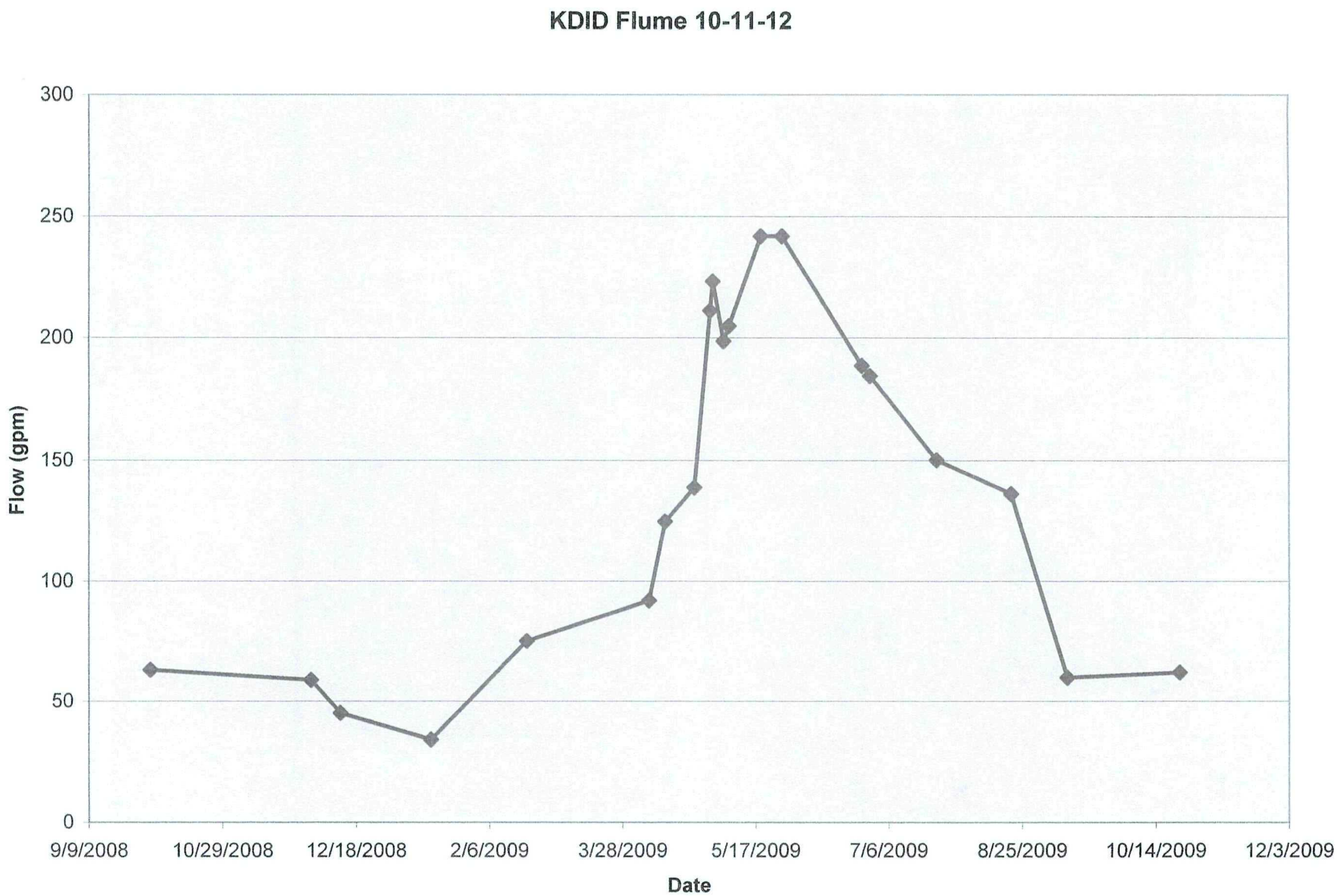


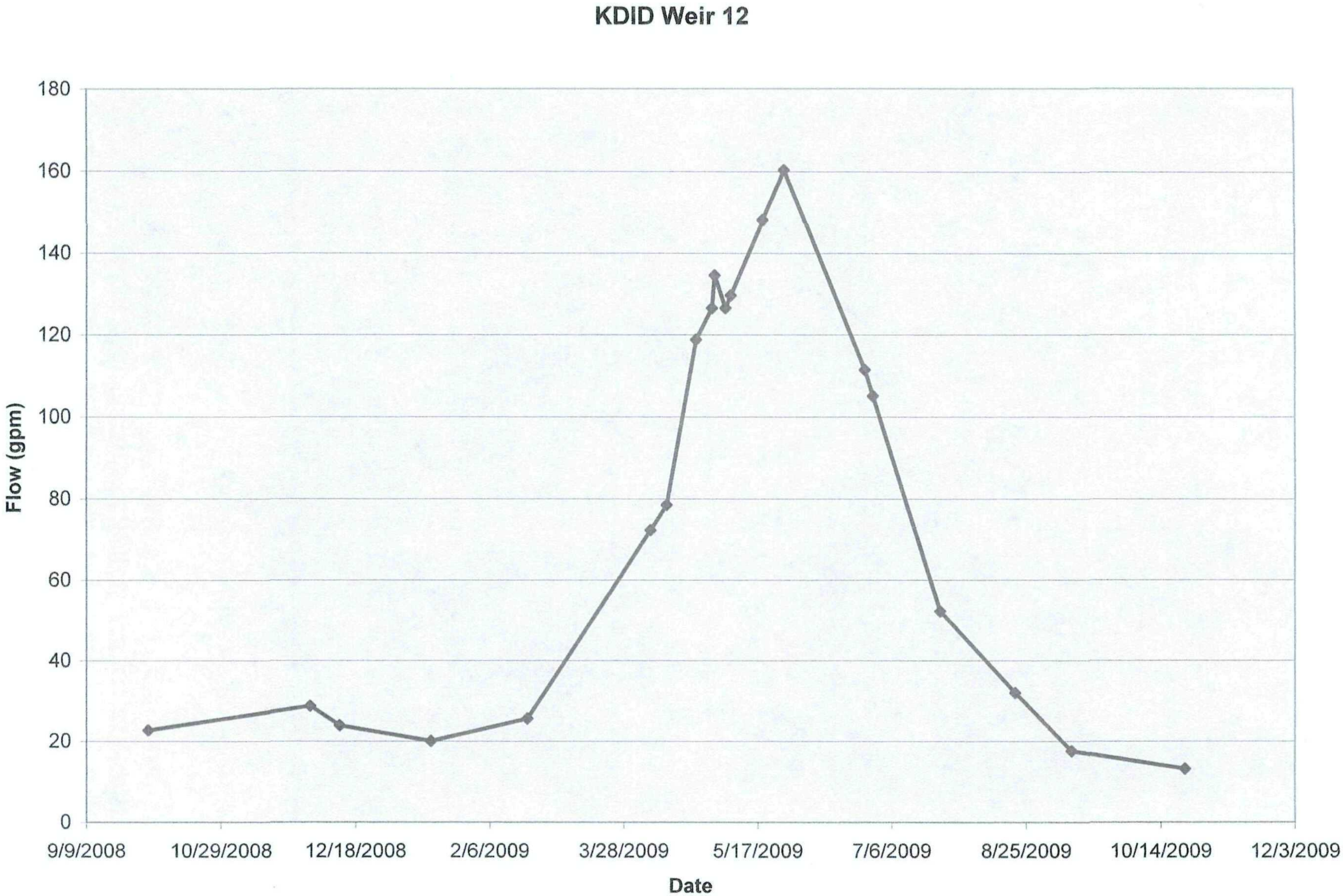
25
20
15
10
5
0
Flow (gpm)
9/9/2008
10/29/2008
12/18/2008
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
Date

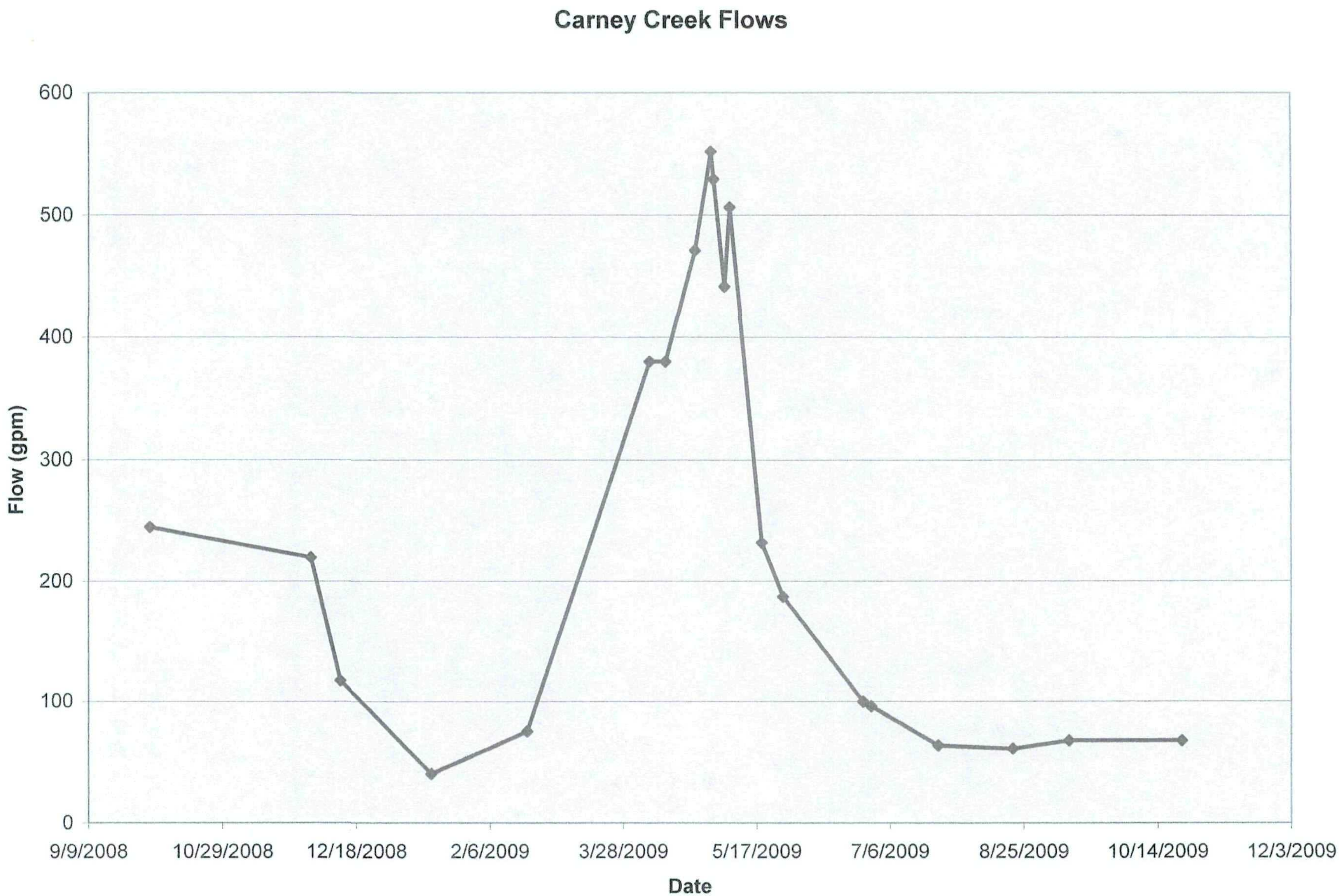

KDID Drain 6 Outflow
Flow (gpm)
900
800
700
600
500
400
300
200
100
0
9/9/2008
10/29/2008
12/18/2008
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
Date

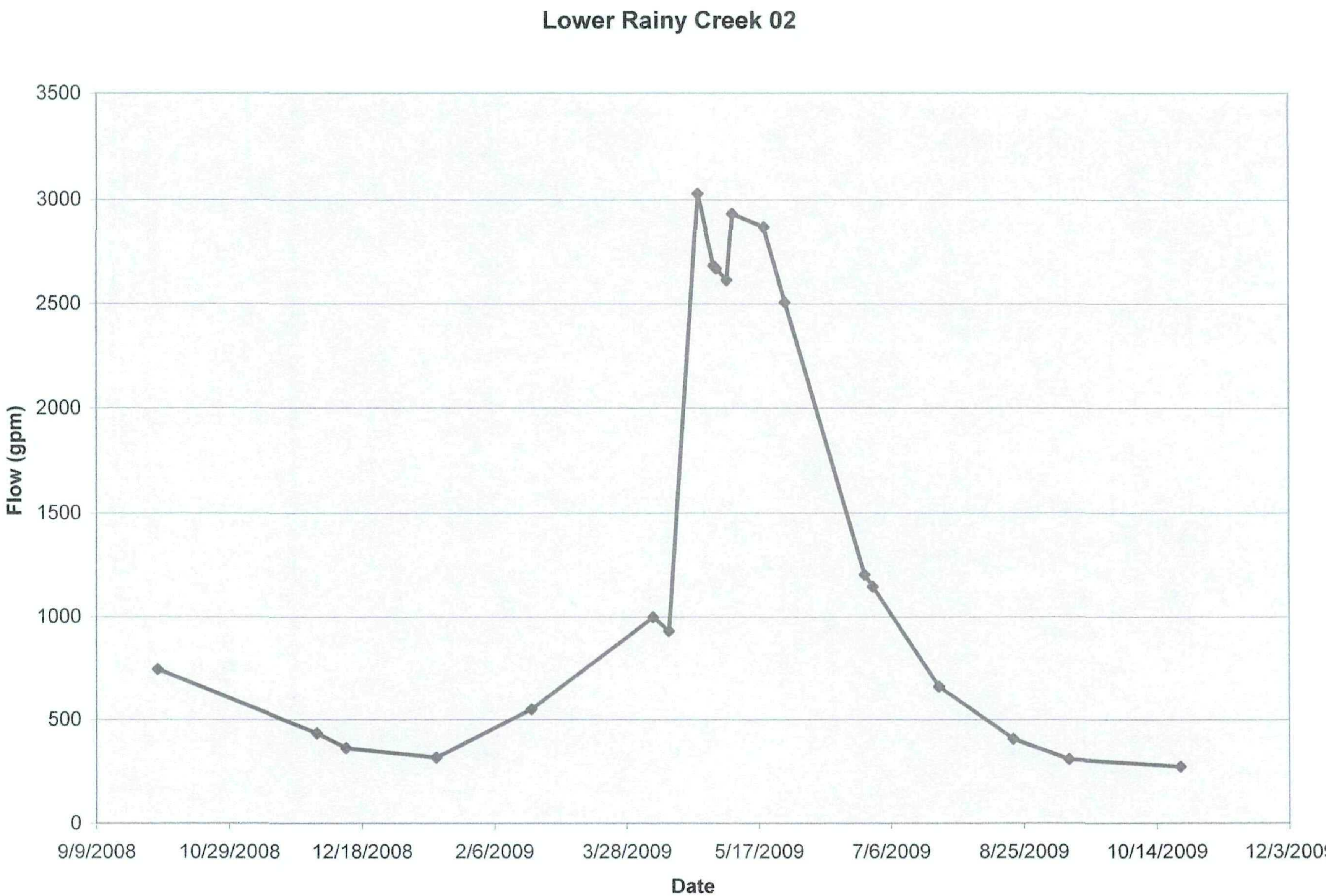


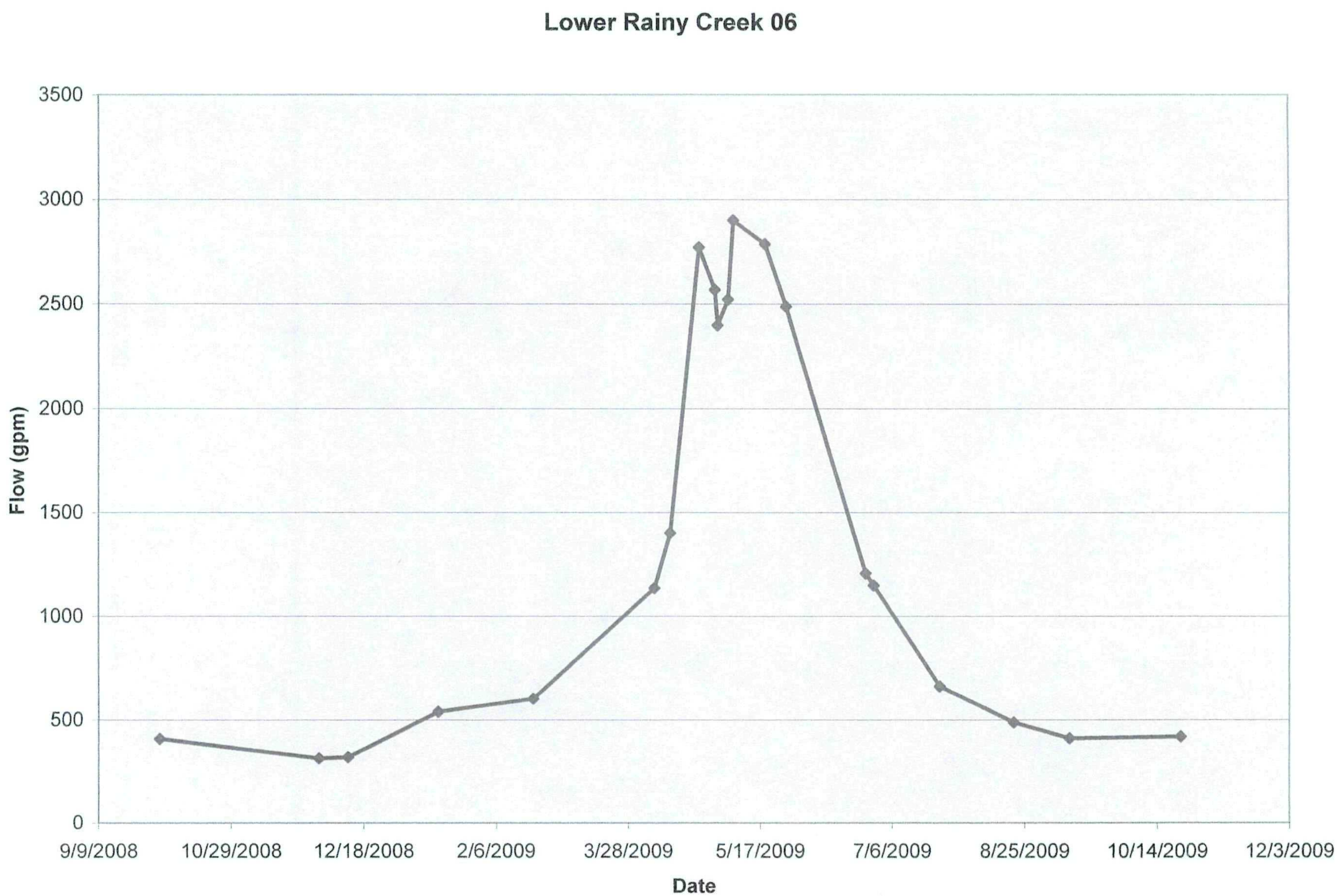
KDID Flume 7-8
Flow (gpm)
0
2
4
6
8
10
12
14
16
18
9/9/2008
10/29/2008
12/18/2008
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
Date

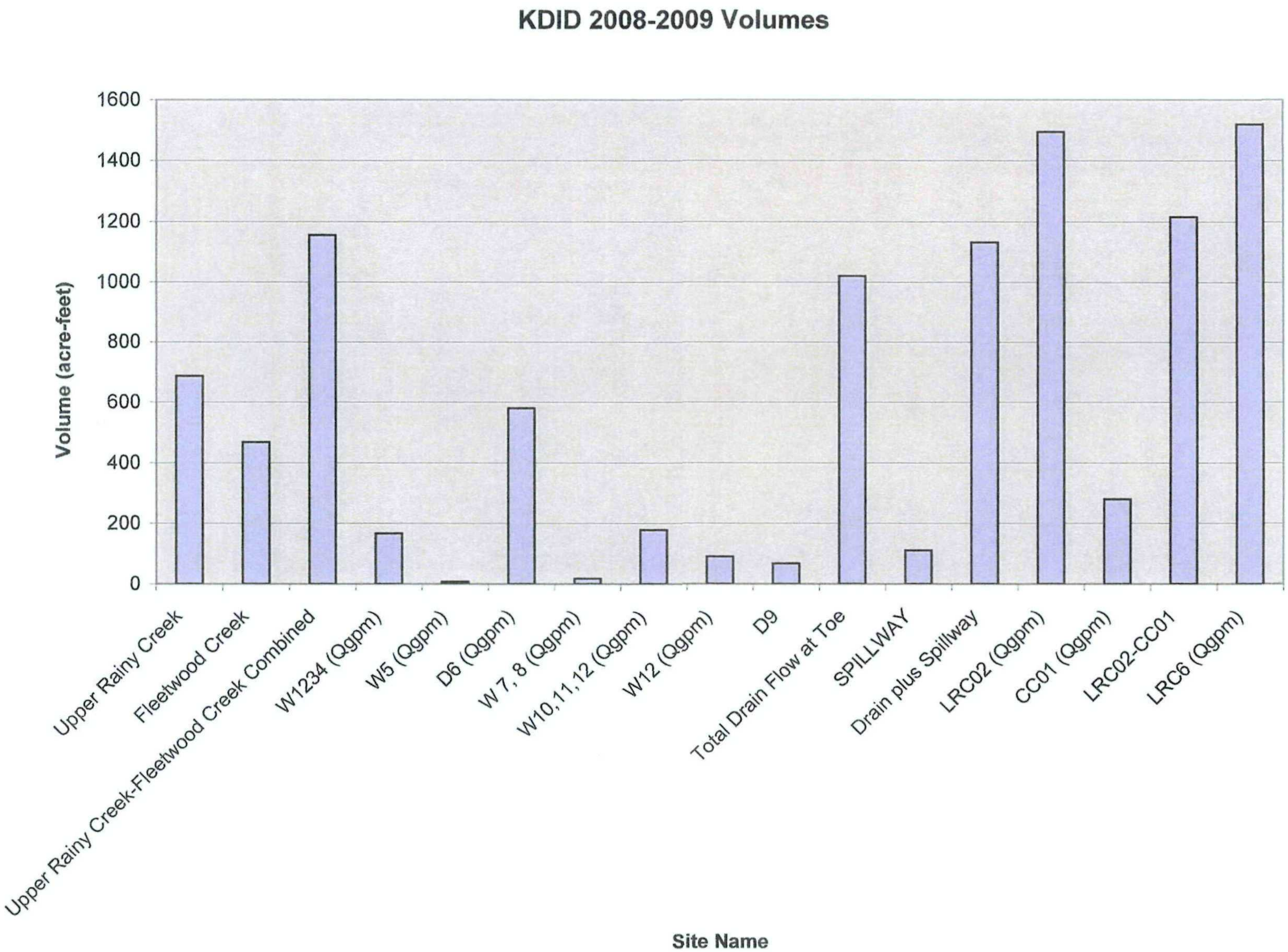

KDID Flume 10-11-12
Flow (gpm)
300
250
200
150
100
50
0
9/9/2008
10/29/2008
12/18/2008
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
Date


KDID Weir 12
Flow (gpm)
0
20
40
60
80
100
120
140
160
180
9/9/2008
10/29/2008
12/18/2008
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
Date


Carney Creek Flows
Flow (gpm)
600
500
400
300
200
100
0
9/9/2008
10/29/2008
12/18/2008
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
Date


Lower Rainy Creek 02
Flow (gpm)
3500
3000
2500
2000
1500
1000
500
0
9/9/2008
10/29/2008
12/18/2008
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
Date


Lower Rainy Creek 06
Flow (gpm)
3500
3000
2500
2000
1500
1000
500
0
9/9/2008
10/29/2008
12/18/2008
2/6/2009
3/28/2009
5/17/2009
7/6/2009
8/25/2009
10/14/2009
12/3/2009
Date


KDID 2008-2009 Volumes
Volume (acre-feet)
0
200
400
600
800
1000
1200
1400
1600
Upper Rainy Creek
Fleetwood Creek
Upper Rainy Creek-Fleetwood Creek Combined
W1234 (Qgpm)
W5 (Qgpm)
D6 (Qgpm)
W 7, 8 (Qgpm)
W10,11,12 (Qgpm)
W12 (Qgpm)
D9
Total Drain Flow at Toe
SPILLWAY
Drain plus Spillway
LRC02 (Qgpm)
CC01 (Qgpm)
LRC02-CC01
LRC6 (Qgpm)
Site Name

APPENDIX C

RATING TABLES

Appendix C Rating Tables

C.1. - 2 ft. H-Flume Rating Table

TRACOM INC.

770.664.6513 (V) 770.664.6565 (F)

Discharge Table For 2.0' H Flume

Document: H20-D-T Rev.: 0 Date: April 6, 2000 By: Jon Wachter

LEVEL		FLOW		
FEET	INCHES	CFS	GPM	MGD
0.01	0.12			
0.02	0.24	0.0014	0.63	0.001
0.03	0.36	0.0031	1.39	0.002
0.04	0.48	0.0050	2.24	0.003
0.05	0.60	0.0073	3.28	0.005
0.06	0.72	0.0100	4.49	0.006
0.07	0.84	0.0130	5.83	0.008
0.08	0.96	0.0166	7.45	0.011
0.09	1.08	0.0205	9.20	0.013
0.10	1.20	0.0248	11.13	0.016
0.11	1.32	0.0293	13.1	0.019
0.12	1.44	0.0341	15.3	0.022
0.13	1.56	0.0392	17.6	0.025
0.14	1.68	0.0447	20.1	0.029
0.15	1.80	0.0505	22.7	0.033
0.16	1.92	0.0567	25.4	0.037
0.17	2.04	0.0632	28.4	0.041
0.18	2.16	0.0701	31.5	0.045
0.19	2.28	0.0774	34.7	0.050
0.20	2.40	0.0850	38.1	0.055
0.21	2.52	0.0930	41.7	0.060
0.22	2.64	0.1015	45.6	0.066
0.23	2.76	0.1103	49.5	0.071
0.24	2.88	0.1195	53.6	0.077
0.25	3.00	0.1290	57.9	0.083
0.26	3.12	0.1390	62.4	0.090
0.27	3.24	0.1494	67.1	0.097
0.28	3.36	0.1602	71.9	0.104
0.29	3.48	0.171	76.9	0.111
0.30	3.60	0.183	82.1	0.118
0.31	3.72	0.195	87.5	0.126
0.32	3.84	0.207	92.9	0.134
0.33	3.96	0.220	98.7	0.142
0.34	4.08	0.234	105.0	0.151
0.35	4.20	0.248	111.3	0.160
0.36	4.32	0.262	117.6	0.169
0.37	4.44	0.276	123.9	0.178
0.38	4.56	0.291	130.6	0.188
0.39	4.68	0.307	137.8	0.198
0.40	4.80	0.323	145.0	0.209
0.41	4.92	0.339	152.1	0.219
0.42	5.04	0.356	159.8	0.230
0.43	5.16	0.374	167.9	0.242
0.44	5.28	0.392	175.9	0.253
0.45	5.40	0.410	184.0	0.265
0.46	5.52	0.429	192.5	0.277
0.47	5.64	0.448	201.1	0.290
0.48	5.76	0.468	210.0	0.302
0.49	5.88	0.488	219.0	0.315
0.50	6.00	0.509	228.4	0.329

LEVEL		FLOW		
FEET	INCHES	CFS	GPM	MGD
0.51	6.12	0.530	237.9	0.343
0.52	6.24	0.552	247.7	0.357
0.53	6.36	0.574	257.6	0.371
0.54	6.48	0.597	267.9	0.386
0.55	6.60	0.620	278.3	0.401
0.56	6.72	0.644	289.0	0.416
0.57	6.84	0.668	299.8	0.432
0.58	6.96	0.693	311.0	0.448
0.59	7.08	0.719	322.7	0.465
0.60	7.20	0.745	334.4	0.481
0.61	7.32	0.771	346.0	0.498
0.62	7.44	0.798	358.1	0.516
0.63	7.56	0.826	370.7	0.534
0.64	7.68	0.854	383.3	0.552
0.65	7.80	0.882	395.8	0.570
0.66	7.92	0.911	408.9	0.589
0.67	8.04	0.941	422.3	0.608
0.68	8.16	0.971	435.8	0.628
0.69	8.28	1.002	449.7	0.648
0.70	8.40	1.03	462.3	0.666
0.71	8.52	1.07	480.2	0.692
0.72	8.64	1.10	493.7	0.711
0.73	8.76	1.13	507.1	0.730
0.74	8.88	1.16	520.6	0.750
0.75	9.00	1.20	538.6	0.776
0.76	9.12	1.23	552.0	0.795
0.77	9.24	1.27	570.0	0.821
0.78	9.36	1.30	583.4	0.840
0.79	9.48	1.34	601.4	0.866
0.80	9.60	1.38	619.3	0.892
0.81	9.72	1.42	637.3	0.918
0.82	9.84	1.46	655.2	0.944
0.83	9.96	1.49	668.7	0.963
0.84	10.08	1.53	686.7	0.989
0.85	10.20	1.57	704.6	1.015
0.86	10.32	1.62	727.1	1.047
0.87	10.44	1.66	745.0	1.073
0.88	10.56	1.70	763.0	1.099
0.89	10.68	1.74	780.9	1.125
0.90	10.80	1.78	798.9	1.150
0.91	10.92	1.83	821.3	1.183
0.92	11.04	1.87	839.3	1.209
0.93	11.16	1.92	861.7	1.241
0.94	11.28	1.96	879.6	1.267
0.95	11.40	2.01	902.1	1.299
0.96	11.52	2.06	924.5	1.331
0.97	11.64	2.10	942.5	1.357
0.98	11.76	2.15	964.9	1.390
0.99	11.88	2.20	987.4	1.422
1.00	12.00	2.25	1009.8	1.454

Source: Field Manual for Research in Agricultural Hydrology, Handbook No. 224, United States Department of Agriculture, February, 1979, pp. 92.

TRACOM INC.

770.664.6513 (V) 770.664.6565 (F)

Discharge Table For 2.0' H Flume

LEVEL		FLOW		
FEET	INCHES	CFS	GPM	MGD
1.01	12.12	2.30	1032.2	1.486
1.02	12.24	2.35	1054.7	1.519
1.03	12.36	2.40	1077.1	1.551
1.04	12.48	2.45	1099.6	1.583
1.05	12.60	2.51	1126.5	1.622
1.06	12.72	2.56	1148.9	1.655
1.07	12.84	2.62	1175.9	1.693
1.08	12.96	2.67	1198.3	1.726
1.09	13.08	2.73	1225.2	1.764
1.10	13.20	2.78	1247.7	1.797
1.11	13.32	2.84	1274.6	1.835
1.12	13.44	2.90	1301.5	1.874
1.13	13.56	2.96	1328.4	1.913
1.14	13.68	3.02	1355.4	1.952
1.15	13.80	3.08	1382.3	1.991
1.16	13.92	3.14	1409.2	2.029
1.17	14.04	3.20	1436.2	2.068
1.18	14.16	3.26	1463.1	2.107
1.19	14.28	3.32	1490.0	2.146
1.20	14.40	3.38	1516.9	2.184
1.21	14.52	3.45	1548.4	2.230
1.22	14.64	3.51	1575.3	2.269
1.23	14.76	3.58	1606.7	2.314
1.24	14.88	3.65	1638.1	2.359
1.25	15.00	3.71	1665.0	2.398
1.26	15.12	3.78	1696.5	2.443
1.27	15.24	3.85	1727.9	2.488
1.28	15.36	3.92	1759.3	2.533
1.29	15.48	3.99	1790.7	2.579
1.30	15.60	4.06	1822.1	2.624
1.31	15.72	4.13	1853.5	2.669
1.32	15.84	4.20	1885.0	2.714
1.33	15.96	4.28	1920.9	2.766
1.34	16.08	4.35	1952.3	2.811
1.35	16.20	4.43	1988.2	2.863
1.36	16.32	4.50	2019.6	2.908
1.37	16.44	4.58	2055.5	2.960
1.38	16.56	4.66	2091.4	3.012
1.39	16.68	4.74	2127.3	3.063
1.40	16.80	4.82	2163.2	3.115
1.41	16.92	4.90	2199.1	3.167
1.42	17.04	4.98	2235.0	3.219
1.43	17.16	5.06	2270.9	3.270
1.44	17.28	5.14	2306.8	3.322
1.45	17.40	5.23	2347.2	3.380
1.46	17.52	5.31	2383.1	3.432
1.47	17.64	5.40	2423.5	3.490
1.48	17.76	5.48	2459.4	3.542
1.49	17.88	5.57	2499.8	3.600
1.50	18.00	5.65	2535.7	3.652

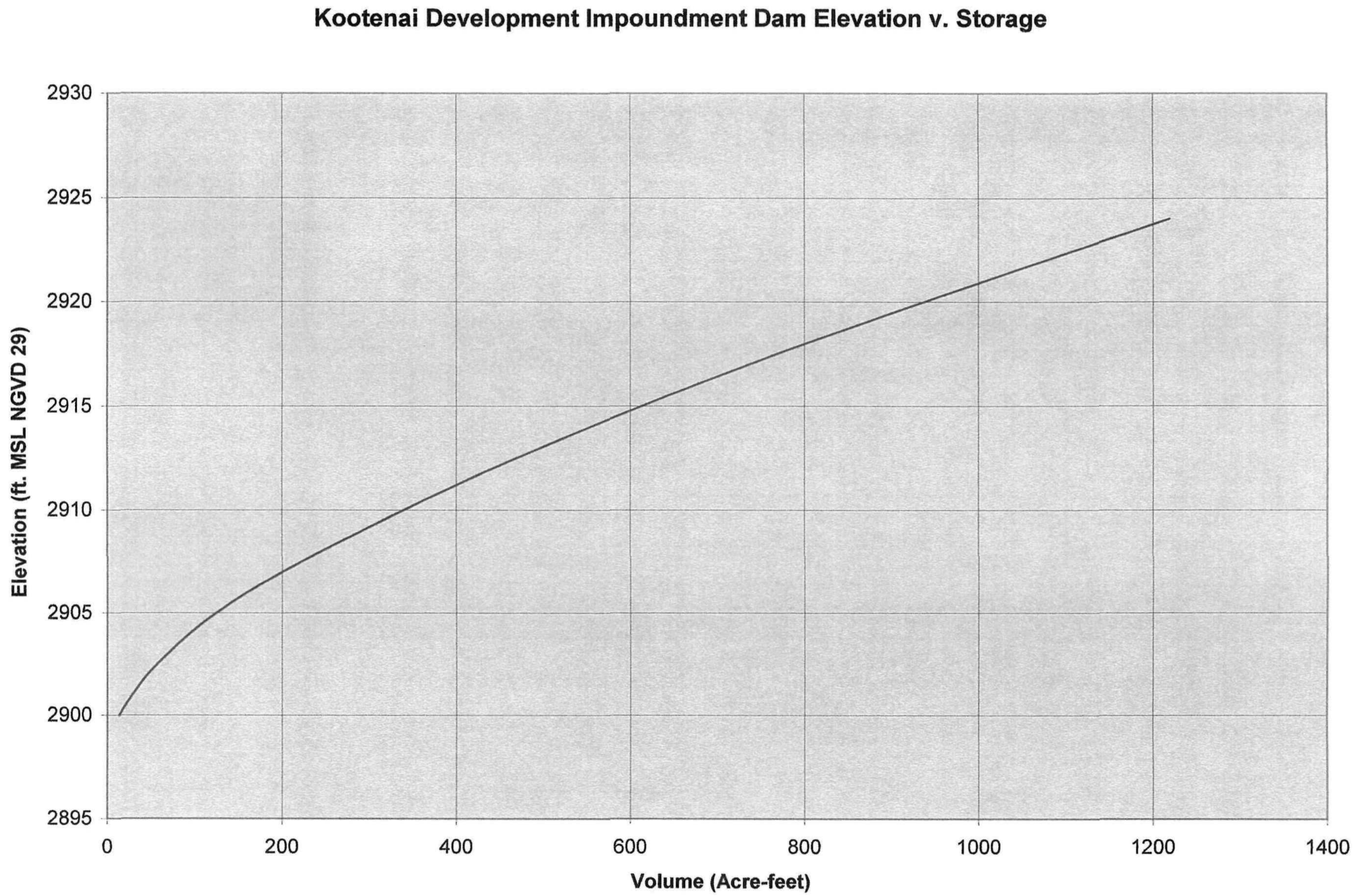
LEVEL		FLOW		
FEET	INCHES	CFS	GPM	MGD
1.51	18.12	5.74	2576.1	3.710
1.52	18.24	5.83	2616.5	3.768
1.53	18.36	5.92	2656.9	3.826
1.54	18.48	6.01	2697.3	3.884
1.55	18.60	6.11	2742.2	3.949
1.56	18.72	6.20	2782.6	4.007
1.57	18.84	6.29	2823.0	4.065
1.58	18.96	6.38	2863.3	4.123
1.59	19.08	6.48	2908.2	4.188
1.60	19.20	6.58	2953.1	4.253
1.61	19.32	6.67	2993.5	4.311
1.62	19.44	6.77	3038.4	4.375
1.63	19.56	6.87	3083.3	4.440
1.64	19.68	6.97	3128.1	4.505
1.65	19.80	7.07	3173.0	4.569
1.66	19.92	7.17	3217.9	4.634
1.67	20.04	7.27	3262.8	4.699
1.68	20.16	7.37	3307.7	4.763
1.69	20.28	7.47	3352.5	4.828
1.70	20.40	7.58	3401.9	4.899
1.71	20.52	7.68	3446.8	4.964
1.72	20.64	7.79	3496.2	5.035
1.73	20.76	7.90	3545.5	5.106
1.74	20.88	8.00	3590.4	5.170
1.75	21.00	8.11	3639.8	5.241
1.76	21.12	8.22	3689.1	5.313
1.77	21.24	8.33	3738.5	5.384
1.78	21.36	8.44	3787.9	5.455
1.79	21.48	8.56	3841.7	5.532
1.80	21.60	8.67	3891.1	5.603
1.81	21.72	8.78	3940.5	5.675
1.82	21.84	8.90	3994.3	5.752
1.83	21.96	9.01	4043.7	5.823
1.84	22.08	9.13	4097.5	5.901
1.85	22.20	9.24	4146.9	5.972
1.86	22.32	9.36	4200.8	6.049
1.87	22.44	9.48	4254.6	6.127
1.88	22.56	9.60	4308.5	6.204
1.89	22.68	9.72	4362.3	6.282
1.90	22.80	9.85	4420.7	6.366
1.91	22.92	9.97	4474.5	6.444
1.92	23.04	10.09	4528.4	6.521
1.93	23.16	10.21	4582.2	6.599
1.94	23.28	10.34	4640.6	6.683
1.95	23.40	10.47	4698.9	6.767
1.96	23.52	10.60	4757.3	6.851
1.97	23.64	10.72	4811.1	6.928
1.98	23.76	10.85	4869.5	7.012
1.99	23.88	10.98	4927.8	7.096

Source: Field Manual for Research in Agricultural Hydrology, Handbook No. 224, United States Department of Agriculture, February, 1979, pp. 92.

C.2. - Reservoir Rating Table

Billmayer Engineering
Kootenai Impoundment Dam Annual Inspection
16-Mar-09
Hafferman
Impoundment Volume by Elevation

Elevation	Volume (in cubic feet)	Volume (in Acre Feet)
2924	3135760	72
2923	3091231	71
2922	3048925	70
2921	3006780	69
2920	2964381	68
2919	2922078	67
2918	2838883	65
2917	2746572	63
2916	2659203	61
2915	2574492	59
2914	2492111	57
2913	2412115	55
2912	2256023	52
2911	2175245	50
2910	2096378	48
2909	2019427	46
2908	1944357	45
2907	1741334	40
2906	1537475	35
2905	1300979	30
2904	1127162	26
2903	987345	23
2902	771987	18
2901	668482	15
2900	583092	13
Total=	53101819	1219


Kootenai Development Impoundment Dam Elevation v. Storage
Elevation (ft. MSL NGVD 29)
2930
2925
2920
2915
2910
2905
2900
2895
0
200
400
600
800
1000
1200
1400
Volume (Acre-feet)

C.3. - Spillway Rating Table

KDID Principal Spillway
Rating Table for Rectangular Channel

Project Description	
Project File	c:\haestad\fmw\kid box .fm2
Worksheet	Open Concrete Chute below Box Culvert
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data		
Mannings Coefficient	0.013	
Channel Slope	0.050000	ft/ft
Bottom Width	8.00	ft

Input Data

	Minimum	Maximum	Increment
Depth	0.0	12.0	0.1 in

Rating Table

Depth (in)	Discharge (gal/min)
0.0	0
0.1	10
0.1	30
0.2	60
0.2	100
0.2	140
0.3	200
0.4	250
0.4	320
0.5	380
0.5	460
0.6	530
0.6	620
0.7	710
0.7	800
0.8	890
0.8	990
0.9	1,100
0.9	1,210
1.0	1,320
1.0	1,440
1.1	1,560
1.1	1,680
1.2	1,810
1.2	1,940

KDID Principal Spillway
Rating Table for Rectangular Channel

Rating Table

Depth (in)	Discharge (gal/min)
1.3	2,080
1.3	2,220
1.4	2,360
1.4	2,510
1.5	2,660
1.5	2,810
1.6	2,970
1.6	3,120
1.7	3,290
1.7	3,450
1.8	3,620
1.8	3,790
1.9	3,970
1.9	4,140
2.0	4,320
2.0	4,510
2.1	4,690
2.1	4,880
2.1	5,080
2.2	5,270
2.2	5,470
2.3	5,670
2.3	5,870
2.4	6,080
2.5	6,280
2.5	6,500
2.6	6,710
2.6	6,930
2.7	7,140
2.7	7,360
2.7	7,590
2.8	7,810
2.8	8,040
2.9	8,270
3.0	8,510
3.0	8,740
3.1	8,980
3.1	9,220
3.2	9,470
3.2	9,710
3.2	9,960
3.3	10,210
3.4	10,460
3.4	10,720
3.5	10,970
3.5	11,230

KDID Principal Spillway
Rating Table for Rectangular Channel

Rating Table

Depth (in)	Discharge (gal/min)
3.6	11,490
3.6	11,760
3.7	12,020
3.7	12,290
3.7	12,560
3.8	12,830
3.9	13,110
3.9	13,380
4.0	13,660
4.0	13,940
4.0	14,220
4.1	14,510
4.2	14,800
4.2	15,080
4.2	15,380
4.3	15,670
4.4	15,960
4.4	16,260
4.5	16,560
4.5	16,860
4.5	17,160
4.6	17,470
4.7	17,770
4.7	18,080
4.7	18,390
4.8	18,700
4.9	19,020
4.9	19,330
5.0	19,650
5.0	19,970
5.1	20,290
5.1	20,610
5.2	20,940
5.2	21,260
5.2	21,590
5.3	21,920
5.4	22,250
5.4	22,590
5.5	22,920
5.5	23,260
5.6	23,600
5.6	23,940
5.7	24,280
5.7	24,630
5.7	24,970
5.8	25,320

C.4. – 1-Foot H-Flume Rating Table
1-Foot-Rectangular Weir

TRACOM INC.

770.664.6513 (V) 770.664.6565 (F)

Discharge Table For 1.0' H Flume

Document: H10-D-T Rev.: 0 Date: April 2, 2000 By: Jon Wachter

LEVEL		FLOW		
FEET	INCHES	CFS	GPM	MGD
0.01	0.12			
0.02	0.24	0.0007	0.31	0.000
0.03	0.36	0.0017	0.76	0.001
0.04	0.48	0.0027	1.21	0.002
0.05	0.60	0.0040	1.80	0.003
0.06	0.72	0.0056	2.51	0.004
0.07	0.84	0.0075	3.37	0.005
0.08	0.96	0.0097	4.35	0.006
0.09	1.08	0.0122	5.48	0.008
0.10	1.20	0.0150	6.73	0.010
0.11	1.32	0.0179	8.03	0.012
0.12	1.44	0.0211	9.47	0.014
0.13	1.56	0.0246	11.0	0.016
0.14	1.68	0.0284	12.7	0.018
0.15	1.80	0.0324	14.5	0.021
0.16	1.92	0.0367	16.5	0.024
0.17	2.04	0.0413	18.5	0.027
0.18	2.16	0.0462	20.7	0.030
0.19	2.28	0.0515	23.1	0.033
0.20	2.40	0.0571	25.6	0.037
0.21	2.52	0.0630	28.3	0.041
0.22	2.64	0.0692	31.1	0.045
0.23	2.76	0.0758	34.0	0.049
0.24	2.88	0.0827	37.1	0.053
0.25	3.00	0.0900	40.4	0.058
0.26	3.12	0.0976	43.8	0.063
0.27	3.24	0.1055	47.3	0.068
0.28	3.36	0.1138	51.1	0.074
0.29	3.48	0.1226	55.0	0.079
0.30	3.60	0.1320	59.2	0.085
0.31	3.72	0.1410	63.3	0.091
0.32	3.84	0.1510	67.8	0.098
0.33	3.96	0.1610	72.3	0.104
0.34	4.08	0.1720	77.2	0.111
0.35	4.20	0.1830	82.1	0.118
0.36	4.32	0.1940	87.1	0.125
0.37	4.44	0.2060	92.5	0.133
0.38	4.56	0.2180	97.8	0.141
0.39	4.68	0.2310	103.7	0.149
0.40	4.80	0.2440	109.5	0.158
0.41	4.92	0.2570	115.3	0.166
0.42	5.04	0.2710	121.6	0.175
0.43	5.16	0.2850	127.9	0.184
0.44	5.28	0.3000	134.6	0.194
0.45	5.40	0.3150	141.4	0.204
0.46	5.52	0.3310	148.6	0.214
0.47	5.64	0.3470	155.7	0.224
0.48	5.76	0.3640	163.4	0.235
0.49	5.88	0.3810	171.0	0.246
0.50	6.00	0.3980	178.6	0.257

LEVEL		FLOW		
FEET	INCHES	CFS	GPM	MGD
0.51	6.12	0.416	186.7	0.269
0.52	6.24	0.434	194.8	0.280
0.53	6.36	0.453	203.3	0.293
0.54	6.48	0.472	211.8	0.305
0.55	6.60	0.492	220.8	0.318
0.56	6.72	0.512	229.8	0.331
0.57	6.84	0.533	239.2	0.344
0.58	6.96	0.554	248.6	0.358
0.59	7.08	0.576	258.5	0.372
0.60	7.20	0.598	268.4	0.386
0.61	7.32	0.621	278.7	0.401
0.62	7.44	0.644	289.0	0.416
0.63	7.56	0.668	299.8	0.432
0.64	7.68	0.692	310.6	0.447
0.65	7.80	0.717	321.8	0.463
0.66	7.92	0.743	333.5	0.480
0.67	8.04	0.769	345.1	0.497
0.68	8.16	0.796	357.2	0.514
0.69	8.28	0.823	369.4	0.532
0.70	8.40	0.851	381.9	0.550
0.71	8.52	0.880	394.9	0.569
0.72	8.64	0.909	408.0	0.587
0.73	8.76	0.939	421.4	0.607
0.74	8.88	0.969	434.9	0.626
0.75	9.00	1.000	448.8	0.646
0.76	9.12	1.031	462.7	0.666
0.77	9.24	1.063	477.1	0.687
0.78	9.36	1.096	491.9	0.708
0.79	9.48	1.129	506.7	0.730
0.80	9.60	1.16	520.6	0.750
0.81	9.72	1.20	538.6	0.776
0.82	9.84	1.23	552.0	0.795
0.83	9.96	1.27	570.0	0.821
0.84	10.08	1.30	583.4	0.840
0.85	10.20	1.34	601.4	0.866
0.86	10.32	1.38	619.3	0.892
0.87	10.44	1.41	632.8	0.911
0.88	10.56	1.45	650.8	0.937
0.89	10.68	1.49	668.7	0.963
0.90	10.80	1.53	686.7	0.989
0.91	10.92	1.57	704.6	1.015
0.92	11.04	1.61	722.6	1.041
0.93	11.16	1.66	745.0	1.073
0.94	11.28	1.70	763.0	1.099
0.95	11.40	1.74	780.9	1.125
0.96	11.52	1.78	798.9	1.150
0.97	11.64	1.83	821.3	1.183
0.98	11.76	1.87	839.3	1.209
0.99	11.88	1.92	861.7	1.241

Source: Field Manual for Research in Agricultural Hydrology, Handbook No. 224, United States Department of Agriculture, February, 1979, pp. 92.

Table A7-3. Discharge of standard suppressed rectangular weirs in ft^3/sec. Computed from the formula $Q = 3.33 L h_1^{1.5}$

Head h_1, ft	Weir Length, L, ft 1.0	1.5	2.0	3.0	4.0	5.0
0.20	0.298	0.447	0.596	0.894	1.19	1.49
.21	.320	.481	.641	.961	1.28	1.60
.22	.344	.515	.687	1.03	1.37	1.72
.23	.367	.551	.735	1.10	1.47	1.84
.24	.392	.587	.783	1.17	1.57	1.96
.25	.416	.624	.833	1.25	1.67	2.08
.26	.441	.662	.883	1.32	1.77	2.21
.27	.467	.701	.934	1.40	1.87	2.34
.28	.493	.740	.987	1.48	1.97	2.47
.29	.520	.780	1.04	1.56	2.08	2.60
.30	.547	.821	1.09	1.64	2.19	2.74
.31	.575	.862	1.15	1.72	2.30	2.87
.32	.603	.904	1.21	1.81	2.41	3.01
.33	.631	.947	1.26	1.89	2.53	3.16
.34	—	.990	1.32	1.98	2.64	3.30
.35	—	1.03	1.38	2.07	2.76	3.45
.36	—	1.08	1.44	2.16	2.88	3.60
.37	—	1.12	1.50	2.25	3.00	3.75
.38	—	1.17	1.56	2.34	3.12	3.90
.39	—	1.22	1.62	2.43	3.24	4.06
.40	—	1.26	1.68	2.53	3.37	4.21
.41	—	1.31	1.75	2.62	3.50	4.37
.42	—	1.36	1.81	2.72	3.63	4.53
.43	—	1.41	1.88	2.82	3.76	4.69
.44	—	1.46	1.94	2.92	3.89	4.86
.45	—	1.51	2.01	3.02	4.02	5.03
.46	—	1.56	2.08	3.12	4.16	5.19
.47	—	1.61	2.15	3.22	4.29	5.36
.48	—	1.66	2.21	3.32	4.43	5.54
.49	—	1.71	2.28	3.43	4.57	5.71
.50	—	1.77	2.35	3.53	4.71	5.89
.51	—	—	2.43	3.64	4.85	6.06
.52	—	—	2.50	3.75	4.99	6.24
.53	—	—	2.57	3.85	5.14	6.42
.54	—	—	2.64	3.96	5.29	6.61
.55	—	—	2.72	4.07	5.43	6.79
.56	—	—	2.79	4.19	5.58	6.98
.57	—	—	2.87	4.30	5.73	7.17
.58	—	—	2.94	4.41	5.88	7.35
.59	—	—	3.02	4.53	6.04	7.55
.60	—	—	3.10	4.64	6.19	7.74
.61	—	—	3.17	4.76	6.35	7.93
.62	—	—	3.25	4.88	6.50	8.13
.63	—	—	3.33	5.00	6.66	8.33
.64	—	—	3.41	5.11	6.82	8.52

Table A7-3 [continued]. Discharge of standard suppressed rectangular weirs in ft^3/sec. Computed from the formula $Q = 3.33 L h_1^{1.5}$

Head h_1, ft	Weir Length, L, ft 2.0	3.0	4.0	5.0
0.65	3.49	5.24	6.98	8.73
.66	3.57	5.36	7.14	8.93
.67	3.65	5.48	7.30	9.13
.68	—	5.60	7.47	9.34
.69	—	5.73	7.63	9.54
.70	—	5.85	7.80	9.75
.71	—	5.98	7.97	9.96
.72	—	6.10	8.14	10.2
.73	—	6.23	8.31	10.4
.74	—	6.36	8.48	10.6
.75	—	6.49	8.65	10.8
.76	—	6.62	8.83	11.0
.77	—	6.75	9.00	11.2
.78	—	6.88	9.18	11.5
.79	—	7.01	9.35	11.7
.80	—	7.15	9.53	11.9
.81	—	7.28	9.71	12.1
.82	—	7.42	9.89	12.4
.83	—	7.55	10.1	12.6
.84	—	7.69	10.3	12.8
.85	—	7.83	10.4	13.0
.86	—	7.97	10.6	13.3
.87	—	8.11	10.8	13.5
.88	—	8.25	11.0	13.7
.89	—	8.39	11.2	14.0
.90	—	8.53	11.4	14.2
.91	—	8.67	11.6	14.5
.92	—	8.82	11.8	14.7
.93	—	8.96	11.9	14.9
.94	—	9.10	12.1	15.2
.95	—	9.25	12.3	15.4
.96	—	9.40	12.5	15.7
.97	—	9.54	12.7	15.9
.98	—	9.69	12.9	16.2
.99	—	9.84	13.1	16.4
1.00	—	9.99	13.3	16.7
1.01	—	—	13.5	16.9
1.02	—	—	13.7	17.2
1.03	—	—	13.9	17.4
1.04	—	—	14.1	17.7
1.05	—	—	14.3	17.9
1.06	—	—	14.5	18.2
1.07	—	—	14.7	18.4
1.08	—	—	14.9	18.7
1.09	—	—	15.2	18.9

Head h_1, ft	Weir Length, L, ft 4.0	5.0
1.10	15.4	19.2
1.11	15.6	19.5
1.12	15.8	19.7
1.13	16.0	20.0
1.14	16.2	20.3
1.15	16.4	20.5
1.16	16.6	20.8
1.17	16.9	21.1
1.18	17.1	21.3
1.19	17.3	21.6
1.20	17.5	21.9
1.21	17.7	22.2
1.22	17.9	22.4
1.23	18.2	22.7
1.24	18.4	23.0
1.25	18.6	23.3
1.26	18.8	23.5
1.27	19.1	23.8
1.28	19.3	24.1
1.29	19.5	24.4
1.30	19.7	24.7
1.31	20.0	25.0
1.32	20.2	25.3
1.33	20.4	25.5
1.34	—	25.8
1.35	—	26.1
1.36	—	26.4
1.37	—	26.7
1.38	—	27.0
1.39	—	27.3
1.40	—	27.6
1.41	—	27.9
1.42	—	28.2
1.43	—	28.5
1.44	—	28.8
1.45	—	29.1
1.46	—	29.4
1.47	—	29.7
1.48	—	30.0
1.49	—	30.3
1.50	—	30.6
1.51	—	30.9
1.52	—	31.2
1.53	—	31.5
1.54	—	31.8

Head h_1, ft	L 5.0
1.55	32.1
1.56	32.4
1.57	32.8
1.58	33.1
1.59	33.4
1.60	33.7
1.61	34.0
1.62	34.3
1.63	34.6
1.64	35.0
1.65	35.3
1.66	35.6
1.67	35.9

C.5. - 90° V-Notch Weir Rating Table

Table A7-4. Discharge of 90° V-notch weirs, in ft^3/sec, computed from the formula $Q = 2.49h_1^{2.48}$.

Head H, ft	Discharge Q, ft³/sec	Head H, ft	Discharge Q, ft³/sec	Head H, ft	Discharge Q, ft³/sec	Head H, ft	Discharge Q, ft³/sec
0.20	0.046	0.65	0.856	1.10	3.15	1.55	7.38
.21	.052	.66	.889	1.11	3.23	1.56	7.50
.22	.058	.67	.922	1.12	3.30	1.57	7.62
.23	.065	.68	.957	1.13	3.37	1.58	7.74
.24	.072	.69	.992	1.14	3.45	1.59	7.86
.25	.080	.70	1.03	1.15	3.52	1.60	7.99
.26	.088	.71	1.06	1.16	3.60	1.61	8.11
.27	.097	.72	1.10	1.17	3.68	1.62	8.24
.28	.106	.73	1.14	1.18	3.75	1.63	8.36
.29	.116	.74	1.18	1.19	3.83	1.64	8.49
.30	.126	.75	1.22	1.20	3.91	1.65	8.62
.31	.136	.76	1.26	1.21	3.99	1.66	8.75
.32	.148	.77	1.30	1.22	4.08	1.67	8.88
.33	.159	.78	1.34	1.23	4.16	1.68	9.02
.34	.172	.79	1.39	1.24	4.25	1.69	9.15
.35	.184	.80	1.43	1.25	4.33	1.70	9.28
.36	.198	.81	1.48	1.26	4.42	1.71	9.42
.37	.212	.82	1.52	1.27	4.50	1.72	9.56
.38	.226	.83	1.57	1.28	4.59	1.73	9.70
.39	.241	.84	1.62	1.29	4.68	1.74	9.83
.40	.257	.85	1.66	1.30	4.77	1.75	9.98
.41	.273	.86	1.71	1.31	4.86	1.76	10.1
.42	.290	.87	1.76	1.32	4.96	1.77	10.3
.43	.307	.88	1.81	1.33	5.05	1.78	10.4
.44	.325	.89	1.87	1.34	5.15	1.79	10.6
.45	.344	.90	1.92	1.35	5.24	1.80	10.7
.46	.363	.91	1.97	1.36	5.34	1.81	10.8
.47	.383	.92	2.02	1.37	5.44	1.82	11.0
.48	.403	.93	2.08	1.38	5.53	1.83	11.1
.49	.425	.94	2.14	1.39	5.63	1.84	11.3
.50	.446	.95	2.19	1.40	5.74	1.85	11.4
.51	.469	.96	2.25	1.41	5.84	1.86	11.6
.52	.492	.97	2.31	1.42	5.94	1.87	11.8
.53	.516	.98	2.37	1.43	6.05	1.88	11.9
.54	.540	.99	2.43	1.44	6.15	1.89	12.1
.55	.565	1.00	2.49	1.45	6.26	1.90	12.2
.56	.591	1.01	2.55	1.46	6.36	1.91	12.4
.57	.618	1.02	2.62	1.47	6.47	1.92	12.6
.58	.645	1.03	2.68	1.48	6.58	1.93	12.7
.59	.673	1.04	2.74	1.49	6.69	1.94	12.9
.60	.701	1.05	2.81	1.50	6.81	1.95	13.0
.61	.731	1.06	2.88	1.51	6.92	1.96	13.2
.62	.761	1.07	2.94	1.52	7.03	1.97	13.4
.63	.792	1.08	3.01	1.53	7.15	1.98	13.5
.64	.823	1.09	3.08	1.54	7.27	1.99	13.7

C.6. – 13-inch Pipe Outfall Rating Table

KDID Drain 6
Drain 6 Rating Table

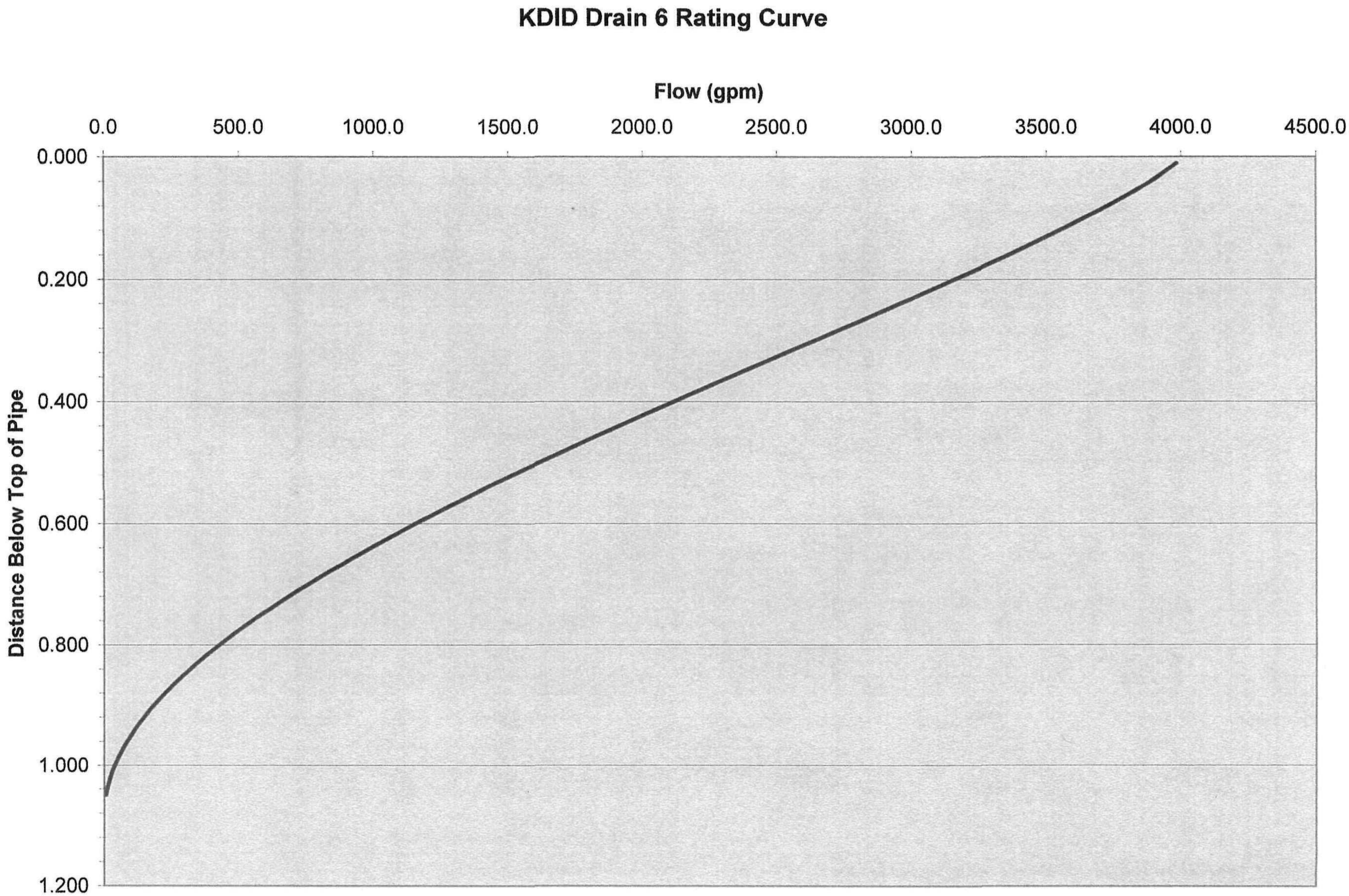
GH below Top of Pipe (ft.)	Flow (gpm)
1.050	6.4
1.040	10.8
1.030	16.2
1.020	22.8
1.010	30.5
1.000	39.3
0.990	49.2
0.980	60.1
0.970	72.1
0.960	85.1
0.950	99.2
0.940	114.2
0.930	130.3
0.920	147.4
0.910	165.5
0.900	184.6
0.890	204.7
0.880	225.7
0.870	247.6
0.860	270.5
0.850	294.4
0.840	319.1
0.830	344.7
0.820	371.2
0.810	398.7
0.810	398.7
0.820	371.2
0.810	398.7
0.800	426.9
0.790	456.1
0.780	486.0
0.770	516.8
0.760	548.5
0.750	580.9
0.740	614.1
0.730	648.1
0.720	682.9
0.71	718.4278
0.7	754.7
0.69	791.7
0.68	829.4
0.67	867.8
0.66	906.9
0.65	946.7
0.64	987.1

KDID Drain 6
Drain 6 Rating Table

GH below Top of Pipe (ft.)	Flow (gpm)
0.63	1028.2
0.62	1069.9
0.6	1155.2
0.59	1198.7
0.58	1242.8
0.57	1287.5
0.56	1332.6
0.55	1378.3
0.54	1424.6
0.53	1471.3
0.52	1518.4
0.51	1566.1
0.5	1614.2
0.49	1662.7
0.48	1711.6
0.47	1760.9
0.46	1810.5
0.45	1860.5
0.44	1910.9
0.43	1961.5
0.42	2012.5
0.41	2063.7
0.4	2115.2
0.39	2166.9
0.38	2218.8
0.37	2270.8
0.36	2323.1
0.35	2375.5
0.34	2427.949
0.33	2480.5
0.32	2533.2
0.31	2585.9
0.3	2638.5
0.29	2691.2
0.28	2743.8
0.27	2796.4
0.26	2848.8
0.25	2901.1
0.24	2953.2
0.23	3005.2
0.22	3056.8
0.21	3108.2
0.2	3159.3
0.19	3210.0
0.18	3260.2

KDID Drain 6
Drain 6 Rating Table

GH below Top of Pipe (ft.)	Flow (gpm)
0.17	3310.1
0.16	3359.4
0.15	3408.1
0.14	3456.3
0.13	3503.7
0.12	3550.4
0.1	3641.3
0.09	3685.3
0.08	3728.1
0.07	3769.8
0.06	3810.1
0.05	3848.8
0.04	3885.9
0.03	3920.8
0.02	3953.4
0.01	3982.9


KDID Drain 6 Rating Curve
Flow (gpm)
0.0
500.0
1000.0
1500.0
2000.0
2500.0
3000.0
3500.0
4000.0
4500.0
Distance Below Top of Pipe
0.000
0.200
0.400
0.600
0.800
1.000
1.200

C.7. – 0.5 Foot H-flume Rating Table

TRACOM INC

770.664.6513 (V) 770.664.6565 (F)

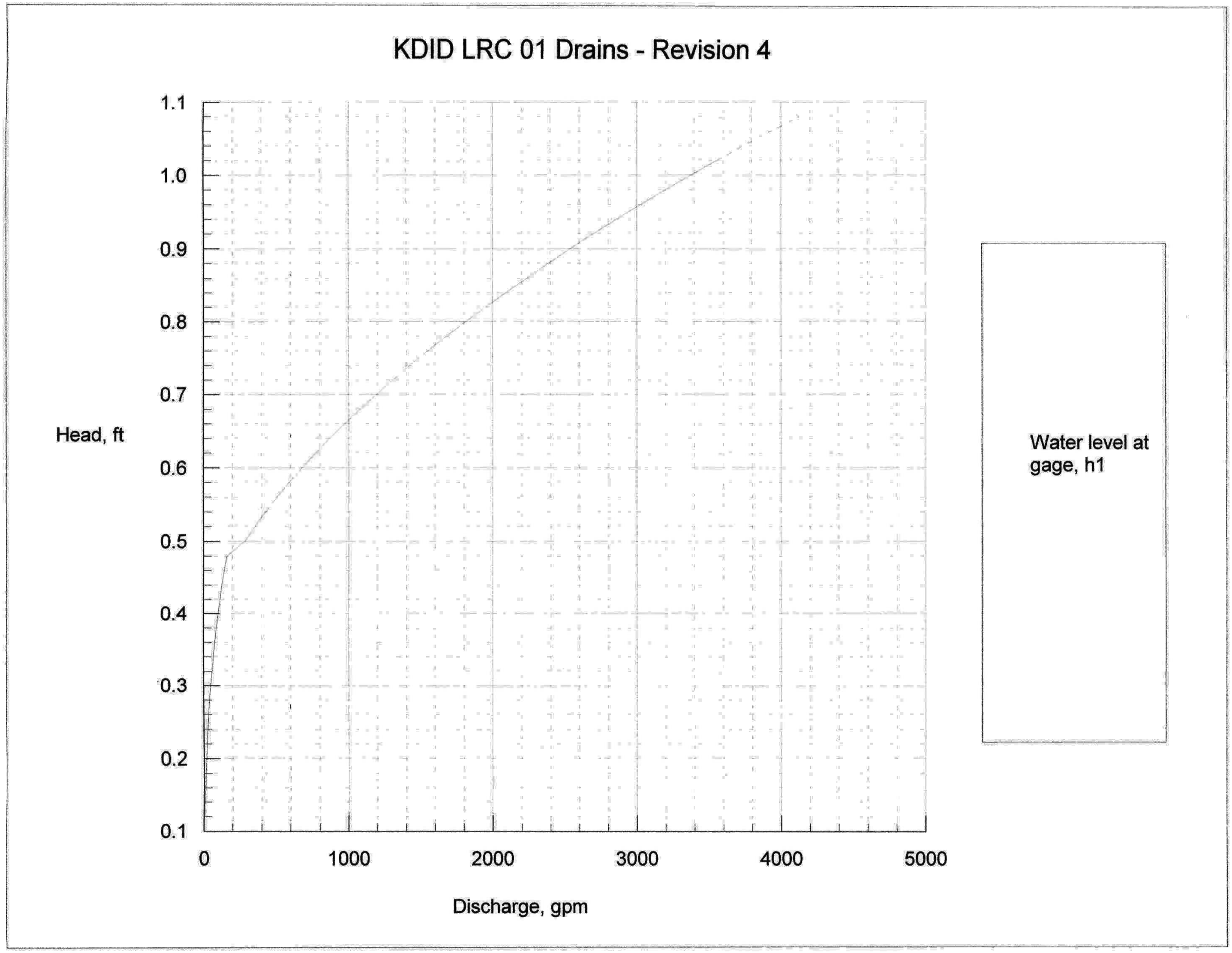
Discharge Table For 0.5' H Flume

Document: H5-D-T Rev.: 0 Date: April 6, 2000 By: Jon Wachter

LEVEL		FLOW		
FEET	INCHES	CFS	GPM	MGD
0.01	0.12			
0.02	0.24	0.0004	0.18	0.000
0.03	0.36	0.0009	0.40	0.001
0.04	0.48	0.0016	0.72	0.001
0.05	0.60	0.0024	1.08	0.002
0.06	0.72	0.0035	1.57	0.002
0.07	0.84	0.0047	2.11	0.003
0.08	0.96	0.0063	2.83	0.004
0.09	1.08	0.0080	3.59	0.005
0.10	1.20	0.0101	4.53	0.007
0.11	1.32	0.0122	5.48	0.008
0.12	1.44	0.0146	6.55	0.009
0.13	1.56	0.0173	7.76	0.011
0.14	1.68	0.0202	9.07	0.013
0.15	1.80	0.0233	10.5	0.015
0.16	1.92	0.0267	12.0	0.017
0.17	2.04	0.0304	13.6	0.020
0.18	2.16	0.0343	15.4	0.022
0.19	2.28	0.0385	17.3	0.025
0.20	2.40	0.0431	19.3	0.028
0.21	2.52	0.0479	21.5	0.031
0.22	2.64	0.0530	23.8	0.034
0.23	2.76	0.0585	26.3	0.038
0.24	2.88	0.0643	28.9	0.042
0.25	3.00	0.0704	31.6	0.045
0.26	3.12	0.0767	34.4	0.050
0.27	3.24	0.0834	37.4	0.054
0.28	3.36	0.0905	40.6	0.058
0.29	3.48	0.0979	43.9	0.063
0.30	3.60	0.1057	47.4	0.068
0.31	3.72	0.1139	51.1	0.074
0.32	3.84	0.1224	54.9	0.079
0.33	3.96	0.1314	59.0	0.085
0.34	4.08	0.1407	63.1	0.091
0.35	4.20	0.1505	67.5	0.097
0.36	4.32	0.1607	72.1	0.104
0.37	4.44	0.1713	76.9	0.111
0.38	4.56	0.1823	81.8	0.118
0.39	4.68	0.1938	87.0	0.125
0.40	4.80	0.2050	92.0	0.132
0.41	4.92	0.2170	97.4	0.140
0.42	5.04	0.2300	103.2	0.149
0.43	5.16	0.2440	109.5	0.158
0.44	5.28	0.2570	115.3	0.166
0.45	5.40	0.2710	121.6	0.175
0.46	5.52	0.2850	127.9	0.184
0.47	5.64	0.3000	134.6	0.194
0.48	5.76	0.3150	141.4	0.204
0.49	5.88	0.3310	148.6	0.214

Source: Field Manual for Research in Agricultural Hydrology, Handbook No. 224, United States Department of Agriculture, February, 1979, pp. 92.

C.8. - Replogle Flume Rating Table


KDID LRC 01 Drains - Revision 4
Head, ft
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1000
2000
3000
4000
5000
Discharge, gpm
Water level at gage, h1

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Head,h1	Discharges in gpm							
ft	0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.
0.12	4.	5.	5.	5.	5.	5.	5.	5.	
0.13	6.	6.	6.	6.	6.	6.	6.	6.	
0.14	7.	7.	7.	7.	7.	7.	7.	8.	
0.15	8.	8.	8.	8.	9.	9.	9.	9.	
0.16	10.	10.	10.	10.	10.	10.	10.	11.	
0.17	11.	11.	11.	12.	12.	12.	12.	12.	
0.18	13.	13.	13.	13.	14.	14.	14.	14.	
0.19	15.	15.	15.	15.	16.	16.	16.	16.	
0.20	17.	17.	17.	18.	18.	18.	18.	19.	
0.21	19.	20.	20.	20.	20.	20.	21.	21.	
0.22	22.	22.	22.	23.	23.	23.	23.	24.	
0.23	24.	25.	25.	25.	25.	26.	26.	26.	
0.24	27.	27.	28.	28.	28.	29.	29.	29.	
0.25	30.	31.	31.	31.	31.	32.	32.	32.	
0.26	33.	34.	34.	34.	35.	35.	35.	36.	
0.27	37.	37.	38.	38.	38.	39.	39.	39.	
0.28	40.	41.	41.	42.	42.	42.	43.	43.	
0.29	44.	45.	45.	45.	46.	46.	47.	47.	
0.30	48.	49.	49.	49.	50.	50.	51.	51.	
0.31	52.	53.	53.	54.	54.	55.	55.	56.	
0.32	57.	57.	58.	58.	59.	59.	60.	60.	
0.33	62.	62.	62.	63.	63.	64.	64.	65.	
0.34	66.	67.	67.	68.	68.	69.	69.	70.	
0.35	72.	72.	73.	73.	74.	74.	75.	75.	
0.36	77.	77.	78.	78.	79.	80.	80.	81.	
0.37	82.	83.	84.	84.	85.	85.	86.	86.	
0.38	88.	89.	89.	90.	91.	91.	92.	92.	
0.39	94.	95.	95.	96.	97.	97.	98.	99.	
0.40	100.	101.	102.	102.	103.	104.	104.	105.	1
0.41	107.	108.	108.	109.	110.	110.	111.	112.	1
0.42	114.	114.	115.	116.	117.	117.	118.	119.	1
0.43	121.	121.	122.	123.	123.	123.	123.	123.	1
0.44	125.	126.	127.	128.	129.	130.	131.	132.	1
0.45	134.	135.	136.	137.	138.	139.	140.	140.	1
0.46	143.	144.	145.	146.	146.	147.	148.	149.	1
0.47	151.	152.	153.	154.	155.	156.	157.	157.	1
0.48	160.	161.	162.	163.	164.	238.	241.	244.	2
0.49	254.	257.	260.	263.	266.	270.	273.	276.	2
0.50	286.	289.	292.	296.	299.	302.	306.	309.	3
0.51	319.	323.	326.	330.	333.	337.	340.	344.	3
0.52	354.	358.	362.	365.	369.	372.	376.	380.	3
0.53	391.	394.	398.	402.	406.	409.	413.	417.	4
0.54	428.	432.	436.	440.	444.	448.	451.	455.	4
0.55	467.	471.	475.	479.	483.	487.	491.	495.	4
0.56	507.	511.	515.	520.	524.	528.	532.	536.	5
0.57	549.	553.	557.	561.	565.	570.	574.	578.	5
0.58	591.	595.	600.	604.	608.	613.	617.	622.	6
0.59	635.	639.	644.	648.	653.	657.	662.	666.	6

User: Billmayer & Hafferman Inc   WinFlume32 - Version 1.05.0030
C:\Program Files\WinFlume\KDID LRC 01 version 4.Flm - Revision 4
KDID LRC 01 Drains
Ditchrider's Rating Table, Printed: 2/18/2010 4:49:29 PM
Page 2

Head,h1 ft	Discharges in gpm 0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.
0.61	726.	731.	735.	740.	745.	749.	754.	759.	7
0.62	773.	778.	783.	788.	792.	797.	802.	807.	8
0.63	822.	827.	831.	836.	841.	846.	851.	856.	8
0.64	871.	876.	881.	886.	891.	896.	902.	907.	9
0.65	922.	927.	932.	937.	943.	948.	953.	958.	9
0.66	974.	979.	984.	990.	995.	1000.	1006.	1011.	10
0.67	1027.	1032.	1038.	1043.	1048.	1054.	1059.	1065.	10
0.68	1081.	1087.	1092.	1098.	1103.	1109.	1114.	1120.	11
0.69	1136.	1142.	1148.	1153.	1159.	1164.	1170.	1176.	11
0.70	1193.	1198.	1204.	1210.	1216.	1221.	1227.	1233.	12
0.71	1250.	1256.	1262.	1268.	1274.	1279.	1285.	1291.	12
0.72	1309.	1315.	1321.	1327.	1332.	1338.	1344.	1350.	13
0.73	1367.	1373.	1379.	1385.	1390.	1396.	1402.	1408.	14
0.74	1426.	1432.	1438.	1444.	1450.	1456.	1463.	1469.	14
0.75	1487.	1493.	1500.	1506.	1512.	1518.	1525.	1531.	15
0.76	1550.	1556.	1563.	1569.	1575.	1582.	1588.	1594.	16
0.77	1614.	1620.	1626.	1633.	1639.	1646.	1652.	1659.	16
0.78	1678.	1685.	1691.	1698.	1705.	1711.	1718.	1724.	17
0.79	1744.	1751.	1758.	1764.	1771.	1778.	1784.	1791.	17
0.80	1811.	1818.	1825.	1831.	1838.	1845.	1852.	1859.	18
0.81	1879.	1886.	1893.	1900.	1907.	1914.	1921.	1927.	19
0.82	1948.	1955.	1962.	1969.	1976.	1983.	1990.	1997.	20
0.83	2019.	2026.	2033.	2040.	2047.	2054.	2061.	2068.	20
0.84	2090.	2097.	2104.	2111.	2119.	2126.	2133.	2140.	21
0.85	2162.	2169.	2177.	2184.	2191.	2199.	2206.	2213.	22
0.86	2236.	2243.	2250.	2258.	2265.	2273.	2280.	2288.	22
0.87	2310.	2318.	2325.	2333.	2340.	2348.	2355.	2363.	23
0.88	2386.	2393.	2401.	2409.	2416.	2424.	2432.	2439.	24
0.89	2462.	2470.	2478.	2486.	2493.	2501.	2509.	2517.	25
0.90	2540.	2548.	2556.	2564.	2572.	2579.	2587.	2595.	26
0.91	2619.	2627.	2635.	2643.	2651.	2659.	2667.	2675.	26
0.92	2699.	2707.	2715.	2723.	2731.	2739.	2747.	2755.	27
0.93	2780.	2788.	2796.	2804.	2813.	2821.	2829.	2837.	28
0.94	2862.	2870.	2878.	2887.	2895.	2903.	2912.	2920.	29
0.95	2945.	2953.	2962.	2970.	2979.	2987.	2995.	3004.	30
0.96	3029.	3038.	3046.	3055.	3063.	3072.	3080.	3089.	30
0.97	3115.	3123.	3132.	3140.	3149.	3158.	3166.	3175.	31
0.98	3201.	3210.	3218.	3227.	3236.	3245.	3253.	3262.	32
0.99	3288.	3297.	3306.	3315.	3324.	3333.	3341.	3350.	33
1.00	3377.	3386.	3395.	3404.	3413.	3422.	3431.	3440.	34
1.01	3467.	3476.	3485.	3494.	3503.	3512.	3521.	3530.	35
1.02	3557.	3566.	3576.	*3585.	*3594.	*3603.	*3612.	*3621.	*36
1.03	*3649.	*3658.	*3668.	*3677.	*3686.	*3695.	*3705.	*3714.	*37
1.04	*3742.	*3751.	*3761.	*3770.	*3779.	*3789.	*3798.	*3808.	*38
1.05	*3836.	*3845.	*3855.	*3864.	*3874.	*3883.	*3893.	*3902.	*39
1.06	*3931.	*3940.	*3950.	*3960.	*3969.	*3979.	*3988.	*3998.	*40
1.07	*4027.	*4037.	*4046.	*4056.	*4066.	*4075.	*4085.	*4095.	*41
1.08	*4124.	--	--	--	--	--	--	--	-

C.9. – 0.75 ft. Parshall Flume Rating Table

Table A8-11. Free-flow discharge through 9-inch Parshall measuring flume in ft^3/sec. Computed from the formula $Q=3.07h_a^{1.53}$

Upper Head h_a, ft	Hundredths 0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.10	0.09	0.10	0.12	0.14	0.15	0.17	0.19	0.20	0.22	0.24
.20	.26	.28	.30	.32	.35	.37	.39	.41	.44	.46
.30	.49	.51	.54	.56	.59	.62	.64	.67	.70	.73
.40	.76	.78	.81	.84	.87	.90	.94	.97	1.00	1.03
.50	1.06	1.10	1.13	1.16	1.20	1.23	1.26	1.30	1.33	1.37
.60	1.41	1.44	1.48	1.51	1.55	1.59	1.63	1.66	1.70	1.74
.70	1.78	1.82	1.86	1.90	1.94	1.98	2.02	2.06	2.10	2.14
.80	2.18	2.22	2.27	2.31	2.35	2.39	2.44	2.48	2.52	2.57
.90	2.61	2.66	2.70	2.75	2.79	2.84	2.88	2.93	2.98	3.02
1.00	3.07	3.12	3.16	3.21	3.26	3.31	3.36	3.40	3.45	3.50
1.10	3.55	3.60	3.65	3.70	3.75	3.80	3.85	3.90	3.95	4.01
1.20	4.06	4.11	4.16	4.21	4.27	4.32	4.37	4.43	4.48	4.53
1.30	4.59	4.64	4.69	4.75	4.80	4.86	4.91	4.97	5.03	5.08
1.40	5.14	5.19	5.25	5.31	5.36	5.42	5.48	5.54	5.59	5.65
1.50	5.71	5.77	5.83	5.88	5.94	6.00	6.06	6.12	6.18	6.24

C.10. – 1 ft. Parshall Flume Rating Table

Rating Table
1.0 ft. Parshall Flume

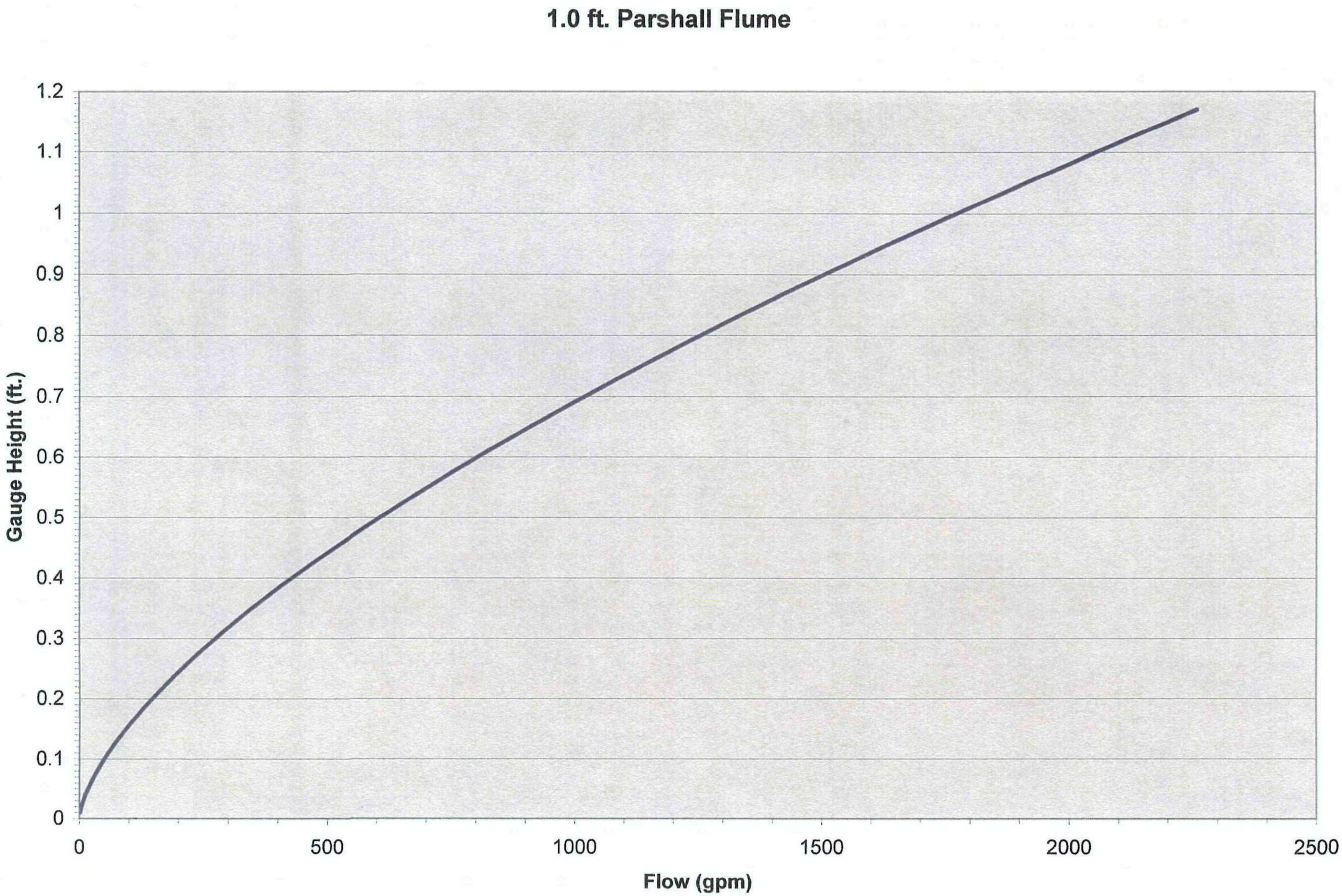
Gauge Height (ft.)	Flow (cfs)	Flow (gpm)
0.01	0.00	1
0.02	0.01	4
0.03	0.02	8
0.04	0.03	12
0.05	0.04	17
0.06	0.05	23
0.07	0.06	29
0.08	0.08	35
0.09	0.09	42
0.1	0.11	50
0.11	0.13	58
0.12	0.15	66
0.13	0.17	75
0.14	0.19	84
0.15	0.21	94
0.16	0.23	104
0.17	0.25	114
0.18	0.28	124
0.19	0.30	135
0.2	0.33	146
0.21	0.35	158
0.22	0.38	170
0.23	0.40	182
0.24	0.43	194
0.25	0.46	207
0.26	0.49	220
0.27	0.52	233
0.28	0.55	247
0.29	0.58	260
0.3	0.61	274
0.31	0.64	289
0.32	0.68	303
0.33	0.71	318
0.34	0.74	333
0.35	0.78	348
0.36	0.81	364
0.37	0.85	380
0.38	0.88	396
0.39	0.92	412
0.4	0.95	428
0.41	0.99	445
0.42	1.03	462
0.43	1.07	479
0.44	1.11	497
0.45	1.15	514
0.46	1.19	532

Rating Table
1.0 ft. Parshall Flume

Gauge Height (ft.)	Flow (cfs)	Flow (gpm)
0.47	1.23	550
0.48	1.27	568
0.49	1.31	587
0.5	1.35	606
0.51	1.39	624
0.52	1.43	644
0.53	1.48	663
0.54	1.52	682
0.55	1.56	702
0.56	1.61	722
0.57	1.65	742
0.58	1.70	762
0.59	1.74	783
0.6	1.79	803
0.61	1.84	824
0.62	1.88	845
0.63	1.93	866
0.64	1.98	888
0.65	2.03	909
0.66	2.07	931
0.67	2.12	953
0.68	2.17	975
0.69	2.22	998
0.7	2.27	1020
0.71	2.32	1043
0.72	2.37	1066
0.73	2.43	1089
0.74	2.48	1112
0.75	2.53	1135
0.76	2.58	1159
0.77	2.63	1183
0.78	2.69	1206
0.79	2.74	1230
0.8	2.80	1255
0.81	2.85	1279
0.82	2.90	1304
0.83	2.96	1328
0.84	3.01	1353
0.85	3.07	1378
0.86	3.13	1404
0.87	3.18	1429
0.88	3.24	1454
0.89	3.30	1480
0.9	3.35	1506
0.91	3.41	1532
0.92	3.47	1558
0.93	3.53	1585

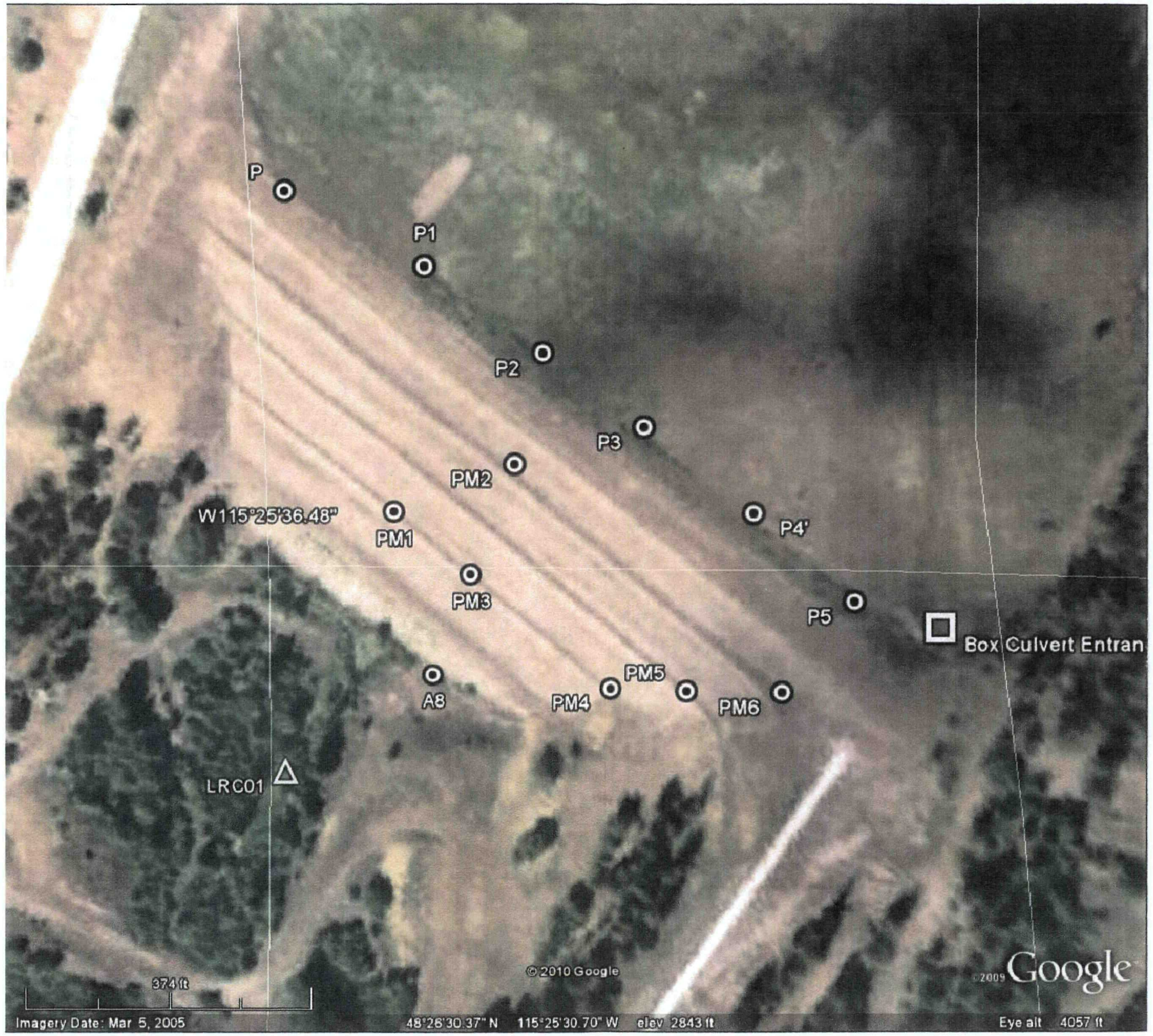
Rating Table
1.0 ft. Parshall Flume

Gauge Height (ft.)	Flow (cfs)	Flow (gpm)
0.94	3.59	1611
0.95	3.65	1638
0.96	3.71	1664
0.97	3.77	1691
0.98	3.83	1718
0.99	3.89	1746
1	3.95	1773
1.01	4.01	1801
1.02	4.07	1828
1.03	4.14	1856
1.04	4.20	1884
1.05	4.26	1912
1.06	4.32	1941
1.07	4.39	1969
1.08	4.45	1998
1.09	4.51	2027
1.1	4.58	2055
1.11	4.64	2084
1.12	4.71	2114
1.13	4.77	2143
1.14	4.84	2172
1.15	4.91	2202
1.16	4.97	2232
1.17	5.04	2262


1.0 ft. Parshall Flume
Gauge Height (ft.)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
500
1000
1500
2000
2500
Flow (gpm)

APPENDIX D

PIEZOMETER DATA AND PLOTS



NORTH

KDID PIEZOMETER LOCATIONS

GARMIN GPS CSx

SCALE : AS SHOWN

REVISIONS | DATE: | DESCRIPTION: | BY:

DRAWN BY: TDL APPROVED BY: J J B

KOOTENAI DEVELOPMENT IMPOUNDMENT DAM

FOR

REMEDIAN GROUP

SECTION 6, T. 28N., R. 21W., P.M., M., FLATHEAD COUNTY

BILLMAYER ENGINEERING
2191 THIRD AVE. E. KALISPELL, MT. 59901
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EMAIL: info@billmayer.com
ONLINE: http://www.billmayer.com

DRAWING TITLE:
PIEZOMETER LOCATIONS

SCALE:
AS SHOWN

DATE: February 18, 2010
PROJECT NO: R.56.1

DRAWING NUMBER:
1 of 1

R.56.1\dwg\piezometer locations.dwg

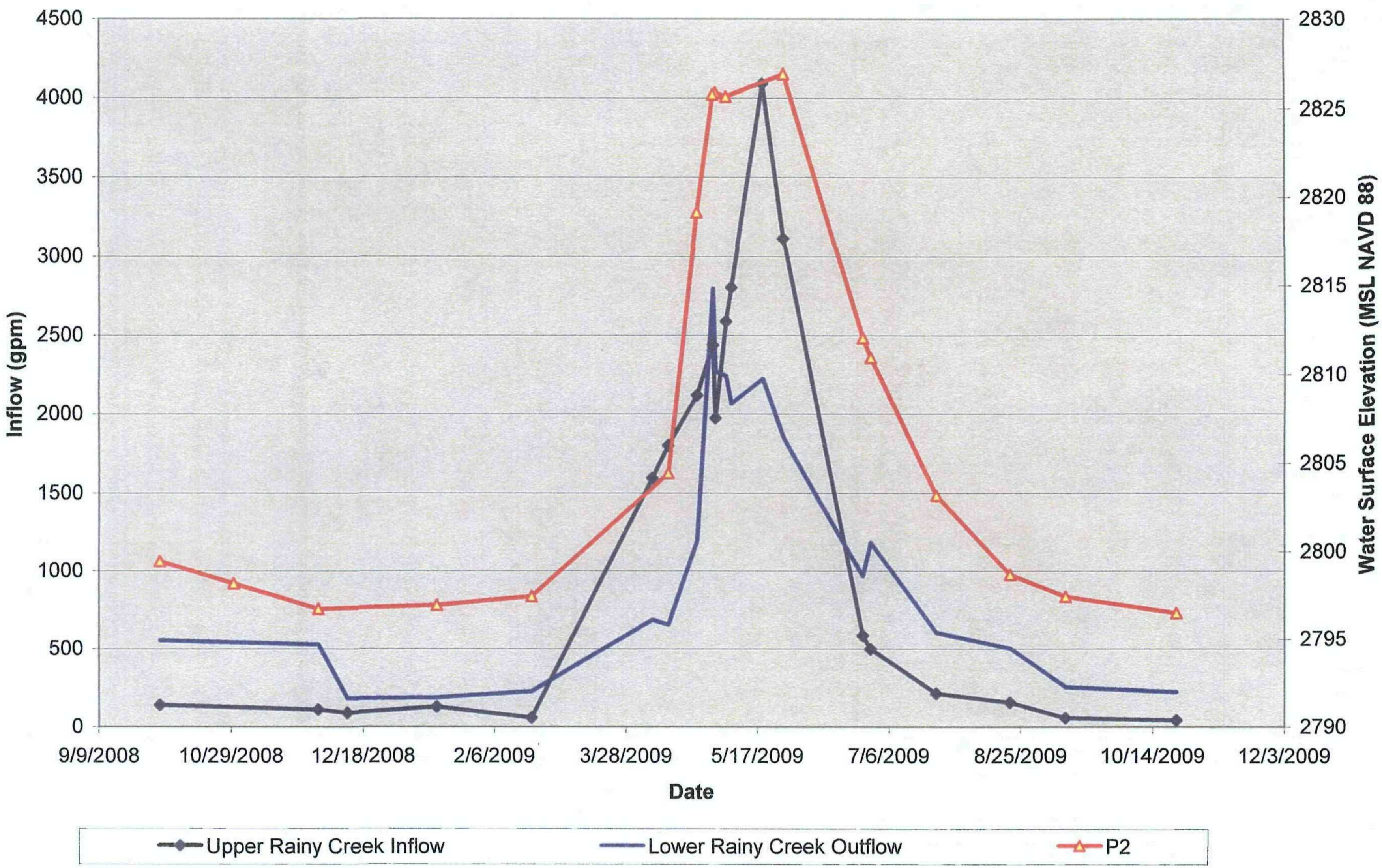
Solinst Levelogger DATA **Kootenai Impoundment Dam**
September 23, 2009

Date	P2 Level	**P2 Levellogger** P2 Level Adj. elevation		Date	A8 Level	**A8 Levellogger** A8 Level Adj. elevation
5/1/2009	23.40	2825.871		5/1/2009	18.34	2789.26
5/2/2009	23.40	2825.87		5/2/2009	18.28	2789.20
5/3/2009	23.40	2825.87		5/3/2009	18.16	2789.08
5/4/2009	23.10	2825.57		5/4/2009	17.97	2788.89
5/5/2009	23.30	2825.77		5/5/2009	18.24	2789.16
5/6/2009	23.60	2826.07		5/6/2009	18.24	2789.16
5/7/2009	24.40	2826.87		5/7/2009	18.55	2789.47
5/8/2009	25.30	2827.77		5/8/2009	18.79	2789.71
5/9/2009	25.70	2828.17		5/9/2009	18.8	2789.72
5/10/2009	25.70	2828.17		5/10/2009	18.63	2789.55
5/11/2009	25.60	2828.07		5/11/2009	18.53	2789.45
5/12/2009	25.90	2828.37		5/12/2009	18.64	2789.56
5/13/2009	26.10	2828.57		5/13/2009	18.67	2789.59
5/14/2009	26.20	2828.67		5/14/2009	18.87	2789.79
5/15/2009	26.60	2829.07		5/15/2009	19.16	2790.08
5/16/2009	26.60	2829.07		5/16/2009	19.09	2790.01
5/17/2009	26.50	2828.97		5/17/2009	18.95	2789.87
5/18/2009	26.10	2828.57		5/18/2009	18.64	2789.56
5/19/2009	26.00	2828.47		5/19/2009	18.87	2789.79
5/20/2009	26.40	2828.87		5/20/2009	19.21	2790.13
5/21/2009	26.80	2829.27		5/21/2009	19.21	2790.13
5/22/2009	26.60	2829.07		5/22/2009	19.13	2790.05
5/23/2009	26.20	2828.67		5/23/2009	19.02	2789.94
5/24/2009	25.90	2828.37		5/24/2009	19.04	2789.96
5/25/2009	25.70	2828.17		5/25/2009	19.13	2790.05
5/26/2009	25.20	2827.67		5/26/2009	19.06	2789.98
5/27/2009	24.90	2827.37		5/27/2009	19.14	2790.06
5/28/2009	24.50	2826.97		5/28/2009	19.14	2790.06
5/29/2009	24.10	2826.57		5/29/2009	19.08	2790.00
5/30/2009	23.50	2825.97		5/30/2009	18.92	2789.84
5/31/2009	23.00	2825.47		5/31/2009	18.95	2789.87
6/1/2009	22.80	2825.27		6/1/2009	19.27	2790.19
6/2/2009	22.10	2824.57		6/2/2009	19.16	2790.08
6/3/2009	21.40	2823.87		6/3/2009	19	2789.92
6/4/2009	20.60	2823.07		6/4/2009	18.84	2789.76
6/5/2009	19.80	2822.27		6/5/2009	18.55	2789.47
6/6/2009	19.30	2821.77		6/6/2009	18.71	2789.63
6/7/2009	18.60	2821.07		6/7/2009	18.62	2789.54
6/8/2009	17.90	2820.37		6/8/2009	18.59	2789.51
6/9/2009	17.40	2819.87		6/9/2009	18.56	2789.48
6/10/2009	16.70	2819.17		6/10/2009	18.39	2789.31
6/11/2009	16.10	2818.57		6/11/2009	18.28	2789.20
6/12/2009	15.50	2817.97		6/12/2009	18.17	2789.09
6/13/2009	15.00	2817.47		6/13/2009	18.08	2789.00
6/14/2009	14.60	2817.07		6/14/2009	18.04	2788.96
6/15/2009	14.30	2816.77		6/15/2009	17.99	2788.91
6/16/2009	13.90	2816.37		6/16/2009	17.84	2788.76

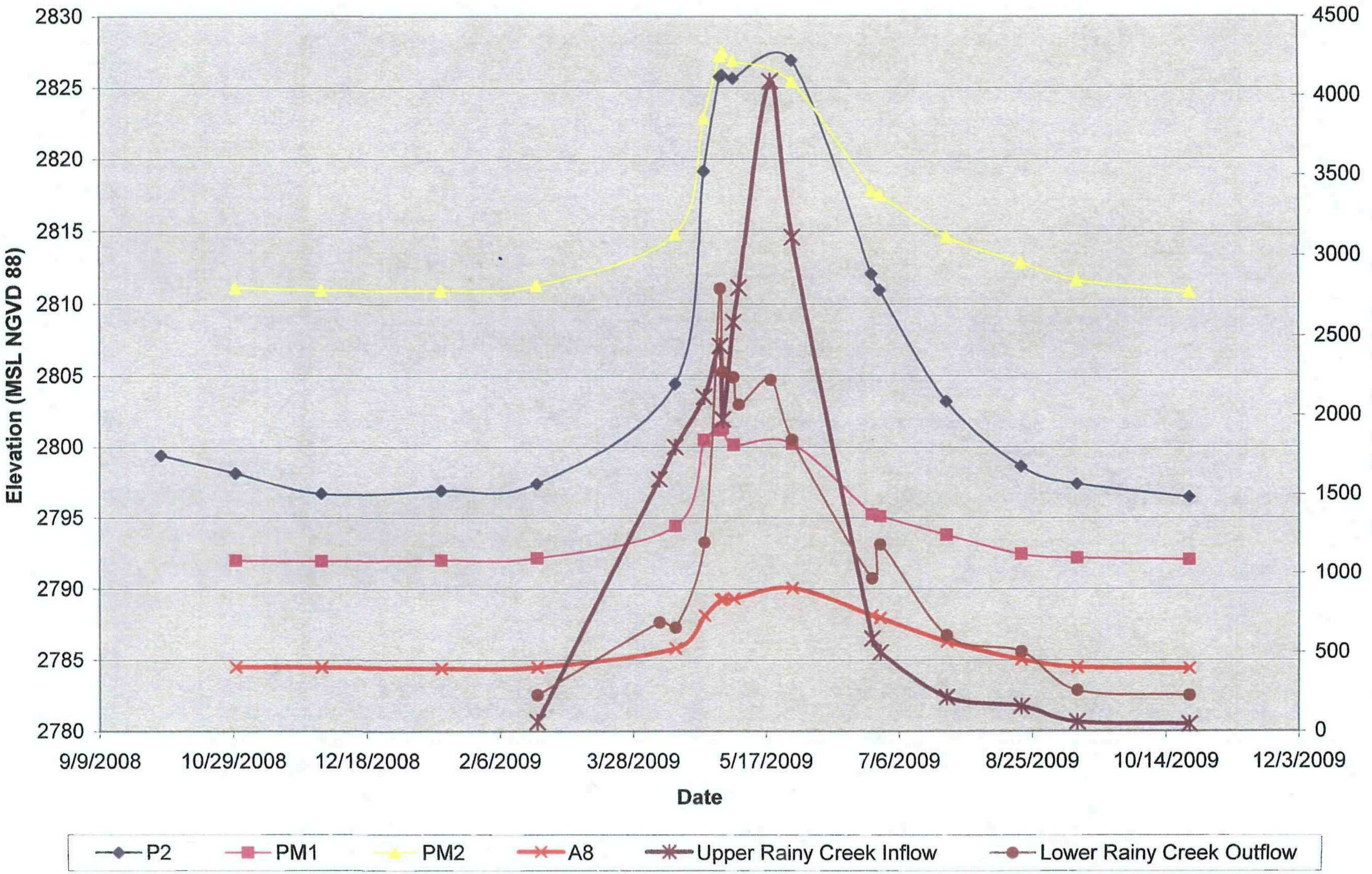
Date	P2 Level	P2 Level Adj. elevation		Date	A8 Level	A8 Level Adj. elevation
6/17/2009	13.50	2815.97		6/17/2009	17.8	2788.72
6/18/2009	13.20	2815.67		6/18/2009	17.66	2788.58
6/19/2009	12.80	2815.27		6/19/2009	17.61	2788.53
6/20/2009	12.30	2814.77		6/20/2009	17.41	2788.33
6/21/2009	11.90	2814.37		6/21/2009	17.41	2788.33
6/22/2009	11.90	2814.37		6/22/2009	17.58	2788.50
6/23/2009	11.40	2813.87		6/23/2009	17.41	2788.33
6/24/2009	10.90	2813.37		6/24/2009	17.19	2788.11
6/25/2009	10.80	2813.27		6/25/2009	17.31	2788.23
6/26/2009	10.40	2812.87		6/26/2009	17.31	2788.23
6/27/2009	10.40	2812.87		6/27/2009	17.31	2788.23
8/5/2009	3.30	2800.74		6/28/2009	17.15	2788.07
8/6/2009	2.70	2801.34		6/29/2009	17	2787.92
8/7/2009	3.20	2800.84		6/30/2009	17.03	2787.95
8/8/2009	3.20	2800.84		7/1/2009	17.03	2787.95
8/9/2009	3.30	2800.74		7/2/2009	16.9	2787.82
8/10/2009	3.40	2800.64		7/3/2009	16.9	2787.82
8/11/2009	3.40	2800.64		7/4/2009	16.74	2787.66
8/12/2009	3.40	2800.64		7/5/2009	16.62	2787.54
8/13/2009	3.40	2800.64		7/6/2009	16.62	2787.54
8/14/2009	3.50	2800.54		7/7/2009	16.56	2787.48
8/15/2009	3.5	2800.54		7/8/2009	16.53	2787.45
8/16/2009	3.6	2800.44		7/9/2009	16.6	2787.52
8/17/2009	3.5	2800.54		7/10/2009	16.56	2787.48
8/18/2009	3.4	2800.64		7/11/2009	16.33	2787.25
8/19/2009	3.5	2800.54		7/12/2009	16.16	2787.08
8/20/2009	3.5	2800.54		7/13/2009	16.24	2787.16
8/21/2009	3.5	2800.54		7/14/2009	16.19	2787.11
8/22/2009	3.4	2800.64		7/15/2009	16.12	2787.04
8/23/2009	3.5	2800.54		7/16/2009	16.1	2787.02
8/24/2009	3.6	2800.44		7/17/2009	16.02	2786.94
8/25/2009	3.5	2800.54		7/18/2009	15.74	2786.66
8/26/2009	3.8	2800.24		7/19/2009	15.81	2786.73
8/27/2009	3.8	2800.24		7/20/2009	15.76	2786.68
8/28/2009	3.7	2800.34		7/21/2009	15.6	2786.52
8/29/2009	3.6	2800.44		7/22/2009	15.51	2786.43
8/30/2009	3.5	2800.54		7/23/2009	15.36	2786.28
8/31/2009	3.5	2800.54		8/6/2009	14.51	2785.43
9/1/2009	3.8	2800.24		8/7/2009	14.71	2785.63
9/2/2009	3.6	2800.44		8/8/2009	14.69	2785.61
9/3/2009	3.8	2800.24		8/9/2009	14.67	2785.59
9/4/2009	2.9	2801.14		8/10/2009	14.6	2785.52
				8/11/2009	14.55	2785.47
				8/12/2009	14.58	2785.50
				8/13/2009	14.5	2785.42
				8/14/2009	14.54	2785.46
				8/15/2009	14.47	2785.39
				8/16/2009	14.59	2785.51
				8/17/2009	14.45	2785.37
				8/18/2009	14.24	2785.16

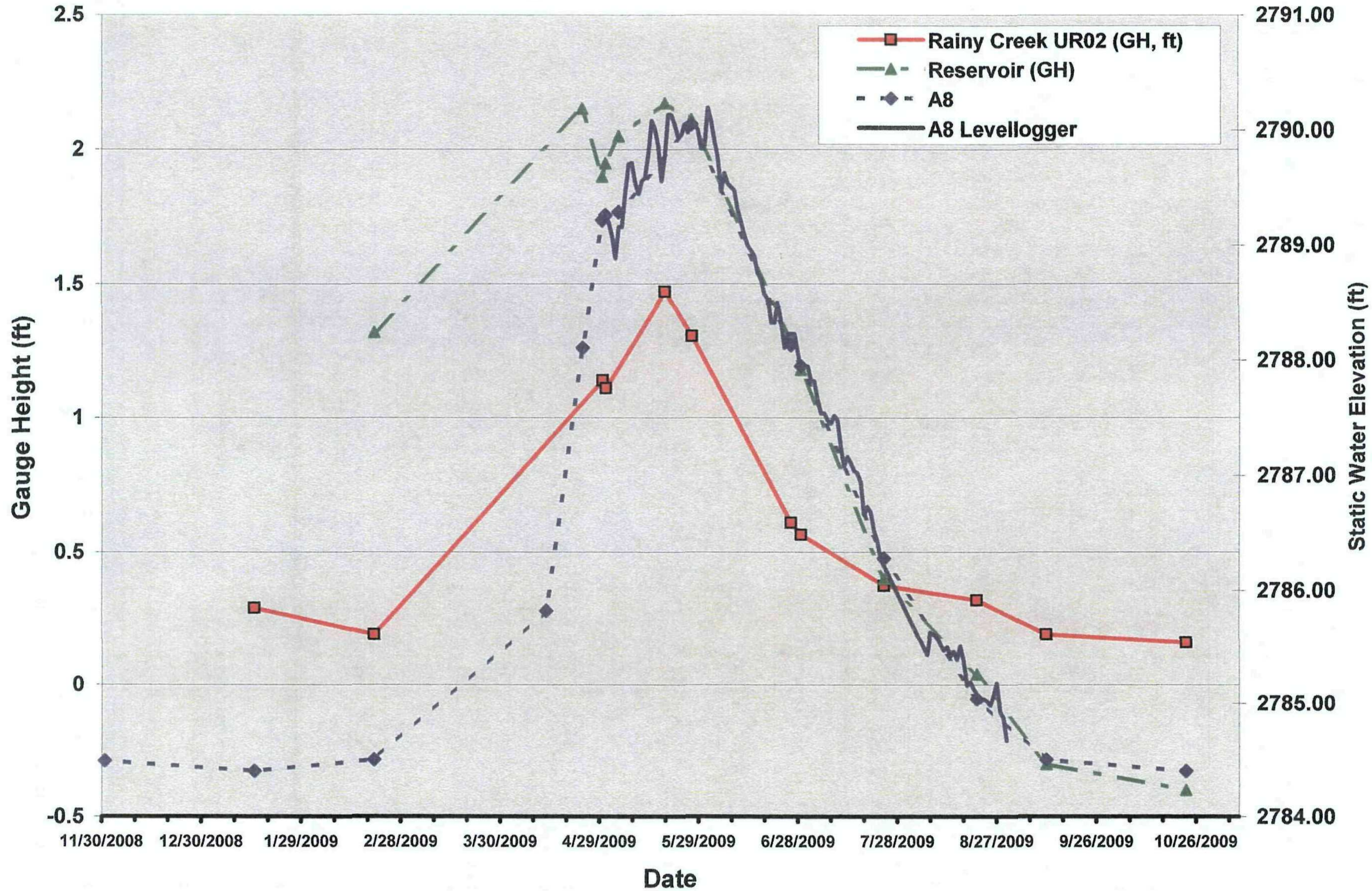
Date	P2 Level	P2 Level Adj. elevation		Date	A8 Level	A8 Level Adj. elevation
				8/19/2009	14.27	2785.19
				8/20/2009	14.21	2785.13
				8/21/2009	14.16	2785.08
				8/22/2009	14.09	2785.01
				8/23/2009	14.12	2785.04
				8/24/2009	14.1	2785.02
				8/25/2009	14.06	2784.98
				8/26/2009	14.14	2785.06
				8/27/2009	14.26	2785.18
				8/28/2009	14	2784.92
				8/29/2009	13.95	2784.87
				8/30/2009	13.75	2784.67

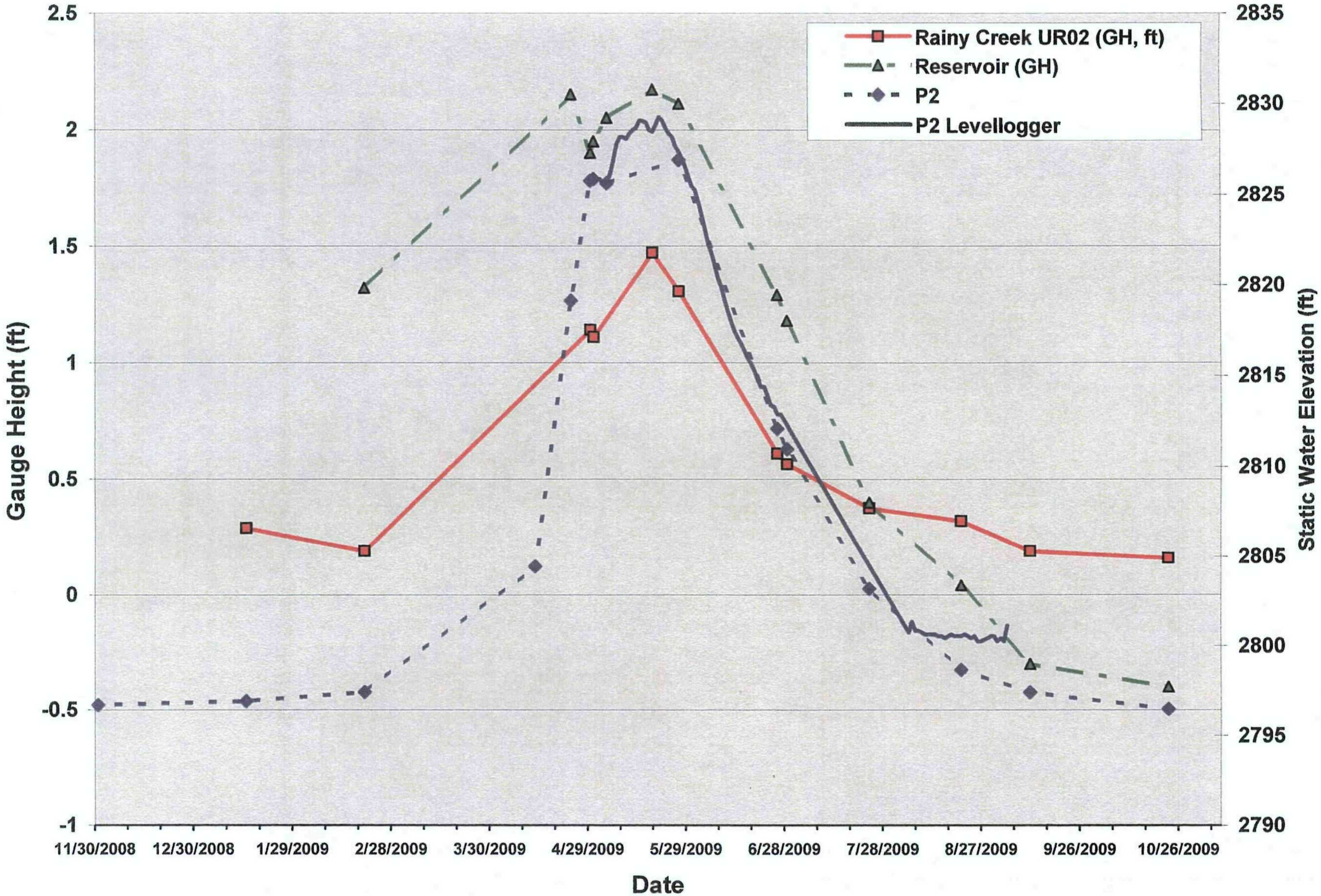
KDID Inflow-Outflow and Piezometer P2



KDID All "Wet" Piezometer Elevations 2008 - 2009




Rainy Creek UR02 (GH, ft)
Reservoir (GH)
A8
A8 Levellogger
Gauge Height (ft)
Static Water Elevation (ft)
Date
2.5
2
1.5
1
0.5
0
-0.5
2791.00
2790.00
2789.00
2788.00
2787.00
2786.00
2785.00
2784.00
11/30/2008
12/30/2008
1/29/2009
2/28/2009
3/30/2009
4/29/2009
5/29/2009
6/28/2009
7/28/2009
8/27/2009
9/26/2009
10/26/2009



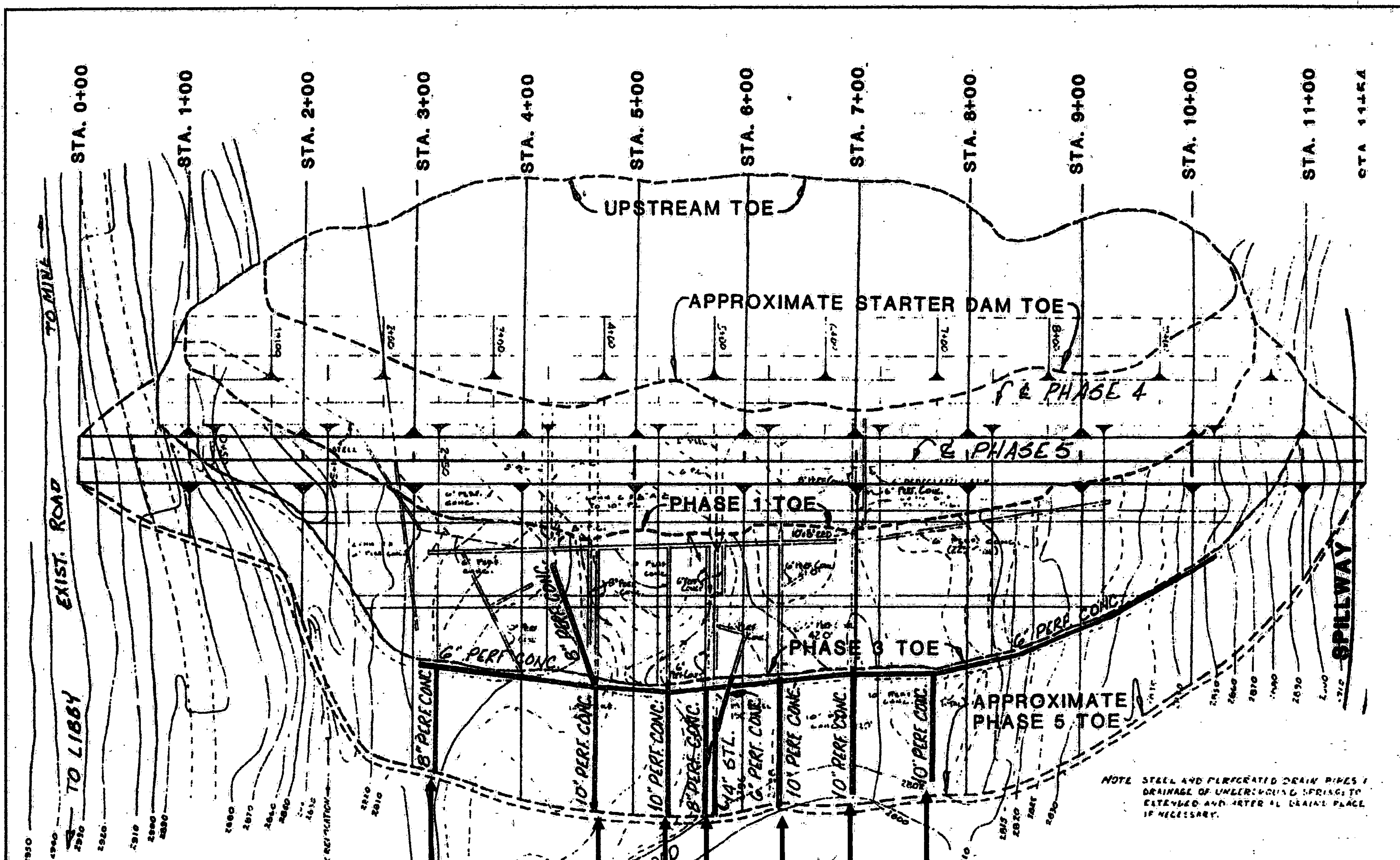
Rainy Creek UR02 (GH, ft)
Reservoir (GH)
P2
P2 Levellogger
Gauge Height (ft)
Static Water Elevation (ft)
Date
2.5
2
1.5
1
0.5
0
-0.5
-1
2835
2830
2825
2820
2815
2810
2805
2800
2795
2790
11/30/2008
12/30/2008
1/29/2009
2/28/2009
3/30/2009
4/29/2009
5/29/2009
6/28/2009
7/28/2009
8/27/2009
9/26/2009
10/26/2009

EMBANKMENT CROSS SECTION AND PIEZOMETER PLOTS DATA ***ELEVATION DATUM: NAD 1983 DATUM***	***KOOTENAI DEVELOPMENT IMPOUNDMENT DAM*** ***KURT HAFFERMAN, P.E.*** ***BILLMAYER & HAFFERMAN INC.***

DISTANCE	Embankment	Highest Recorded Seasonal Phreatic Water Surface	Lowest Piezometer Casing Bottom (A8)	Lowest Recorded Seasonal Phreatic Water Surface	Harding Lawson Theoritical High Phreatic Water Surface	
0	2792.7	2792.7	2764.5	2792.7	2792.7	At Toe of Embankment
108	2845.1	2808.07	2764.5	2801.7	2837	
114	2845.1	2808.9	2764.5	2802.7	2839.4	
171	2871.77	2817.03	2764.5	2806.9	2859.8	
177	2871.77	2817.89	2764.5	2807.4	2862	
231.4	2902.6	2825.79	2764.5	2812	2878.7	
238.5	2902.6	2826.6	2764.5	2812.25	2880	
288.5	2927.6	2831	2764.5	2813.8	2887.5	
328.5	2927.6	2833.9	2764.5	2814.2	2891.1	
348.5	2916	2834.3	2764.5	2814.2	2891.5	
370	2902	2835.6	2764.5	2814.2	2891.5	
1400	2901	2901				At Reservoir

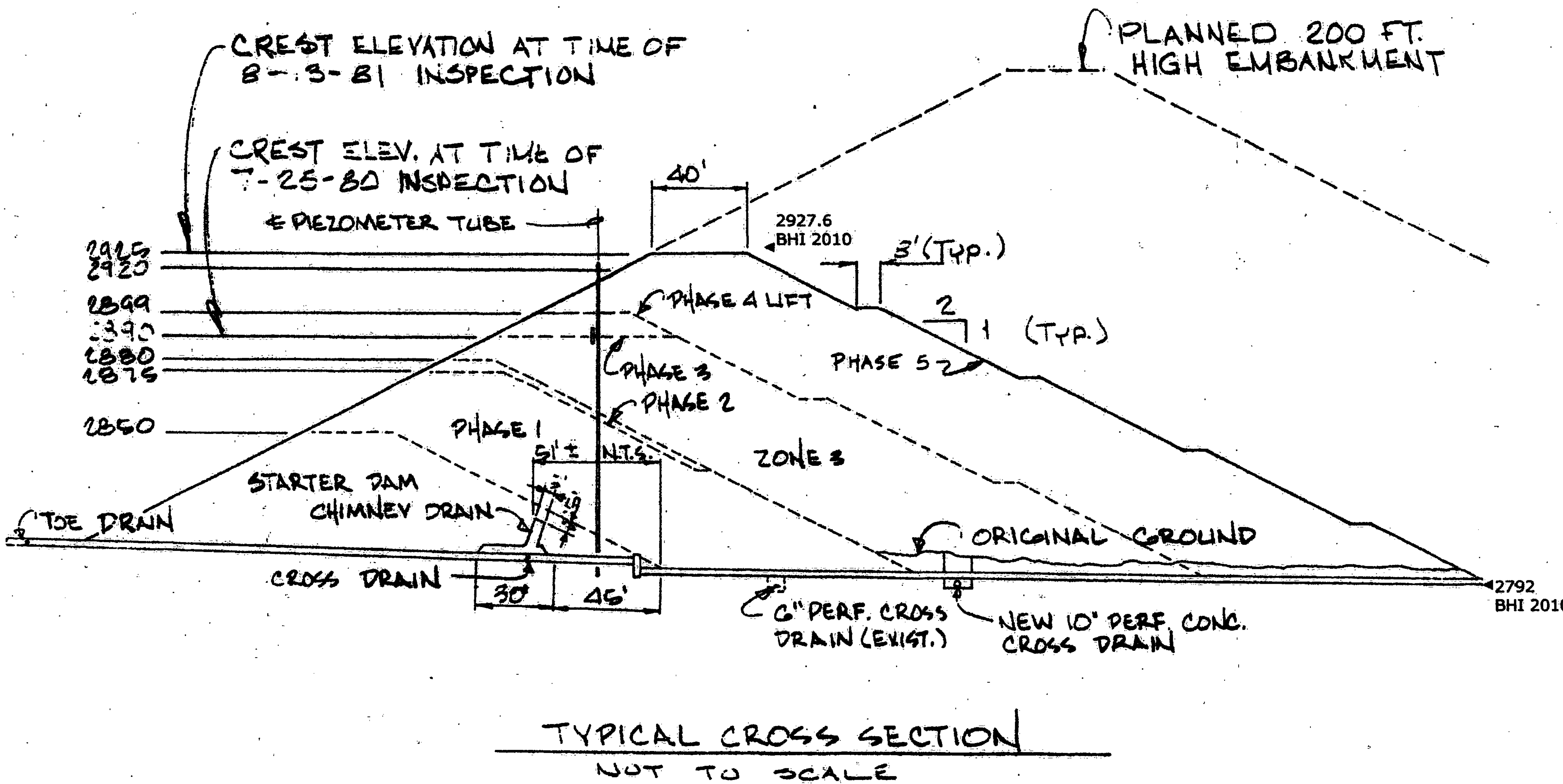
APPENDIX E

PHASE 1 PLAN VIEW AND CROSS SECTION



Proposed Toe Drain Locations

BHI 2009 Not to Scale



ZONOLITE TAILINGS DAM

PHASE 5 ADDITION

PLATE 5